Locational Based Marginal Pricing

Mathangi Srinivasan Kumar
Program Lead, Market Training, NYISO

New York Market Orientation Course (NYMOC)
June 3-5, 2025
Remote Learning

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Benefits to Understanding

- Locational Based Marginal Pricing
  - Your Business Decisions
    - Be better informed for your bidding, forecasting, and investing decisions through understanding the price signals being sent
  - Your Financial Results
    - Understanding payments and charges on your invoice

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Locational Based Marginal Pricing

- SESSION OBJECTIVES:
  - Understand the Basics Behind LBMP
    - Definition
    - Show how LBMPs are Established
    - Name the Three Components of LBMP
  - Complete Examples that Demonstrate LBMP Concepts
  - Learn about the process of Price Validation

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LBMP - Defined

- A methodology where the price of Energy at each location in the NYS Transmission System/NYCA is equivalent to the cost to supply the next increment of Load at that location.

- The cost to provide the next MW of Load at a specific location in the grid is the Marginal Price (LBMP)

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LBMP – The Basics

- LBMP is established for the Day Ahead and the Real Time Markets
  - Day Ahead Market
    - Security Constrained Unit Commitment (SCUC)
    - Hourly Prices
  - Real Time Market
    - Real Time Dispatch (RTD)
    - 5 Minute Interval Prices

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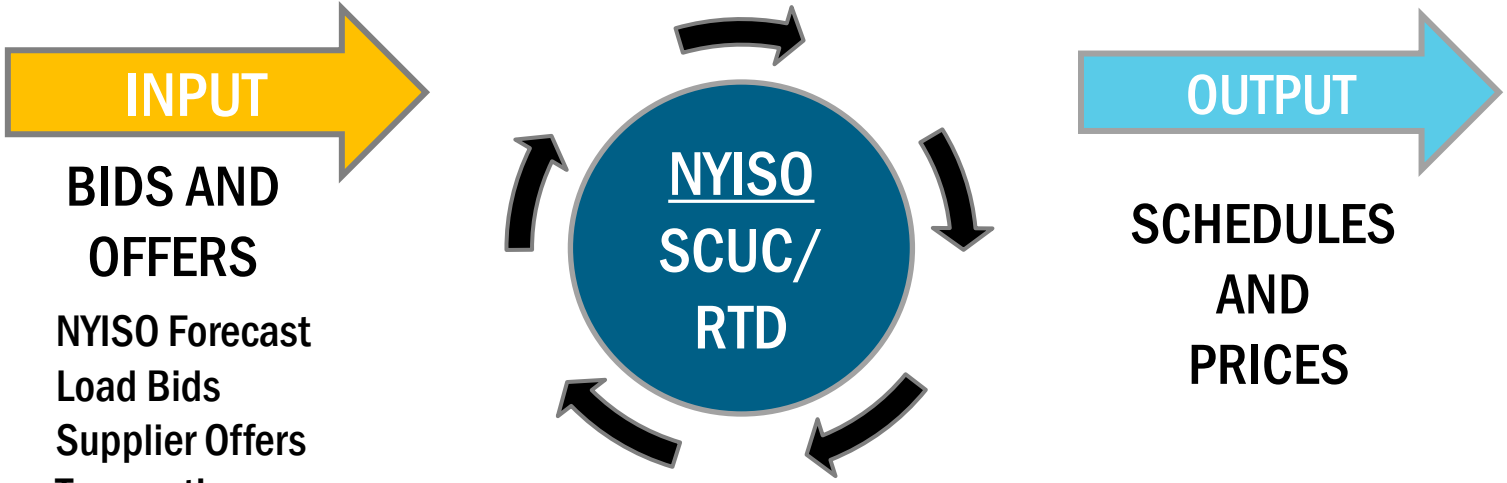
LBMP: Co-Optimized Based on Bids and Offers



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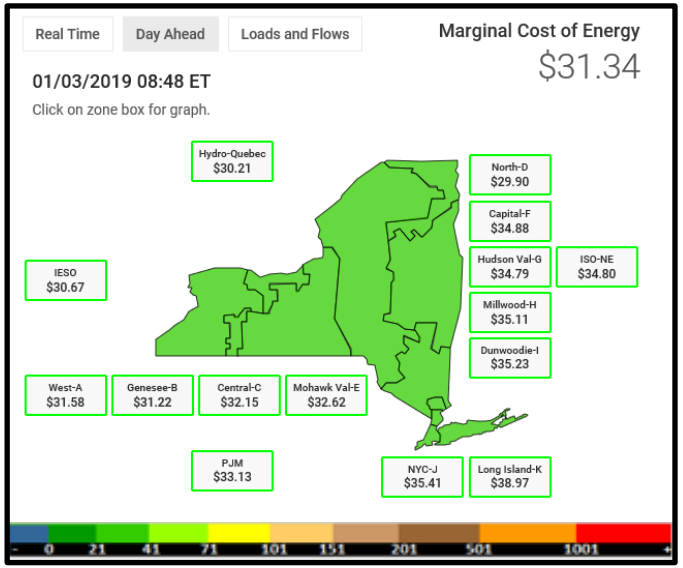
LBMP - Established

- System is bid-based
  - Offers/Bids are Confidential
  - LBMPs are published, keeping market visible



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LBMP Components

- Three Components Comprise the LBMP
  - Marginal Energy Price Component
  - Marginal Loss Price Component
  - Marginal Congestion Price Component

LBMP = Energy + Loss - Congestion

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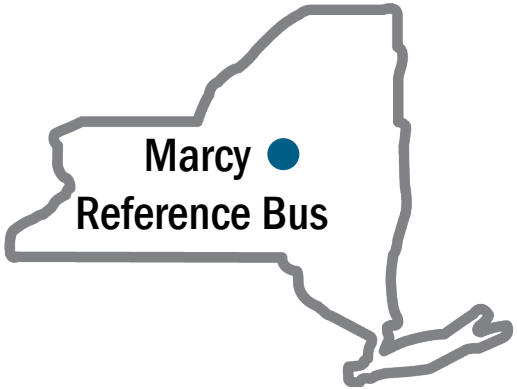
LBMP Components - Energy

- Marginal Energy Price Component
  - Basic component of the LBMP at all buses in system – NYISO Reference Bus (Marcy), posted on NYISO site as: "NYISO_LBMP_Reference"



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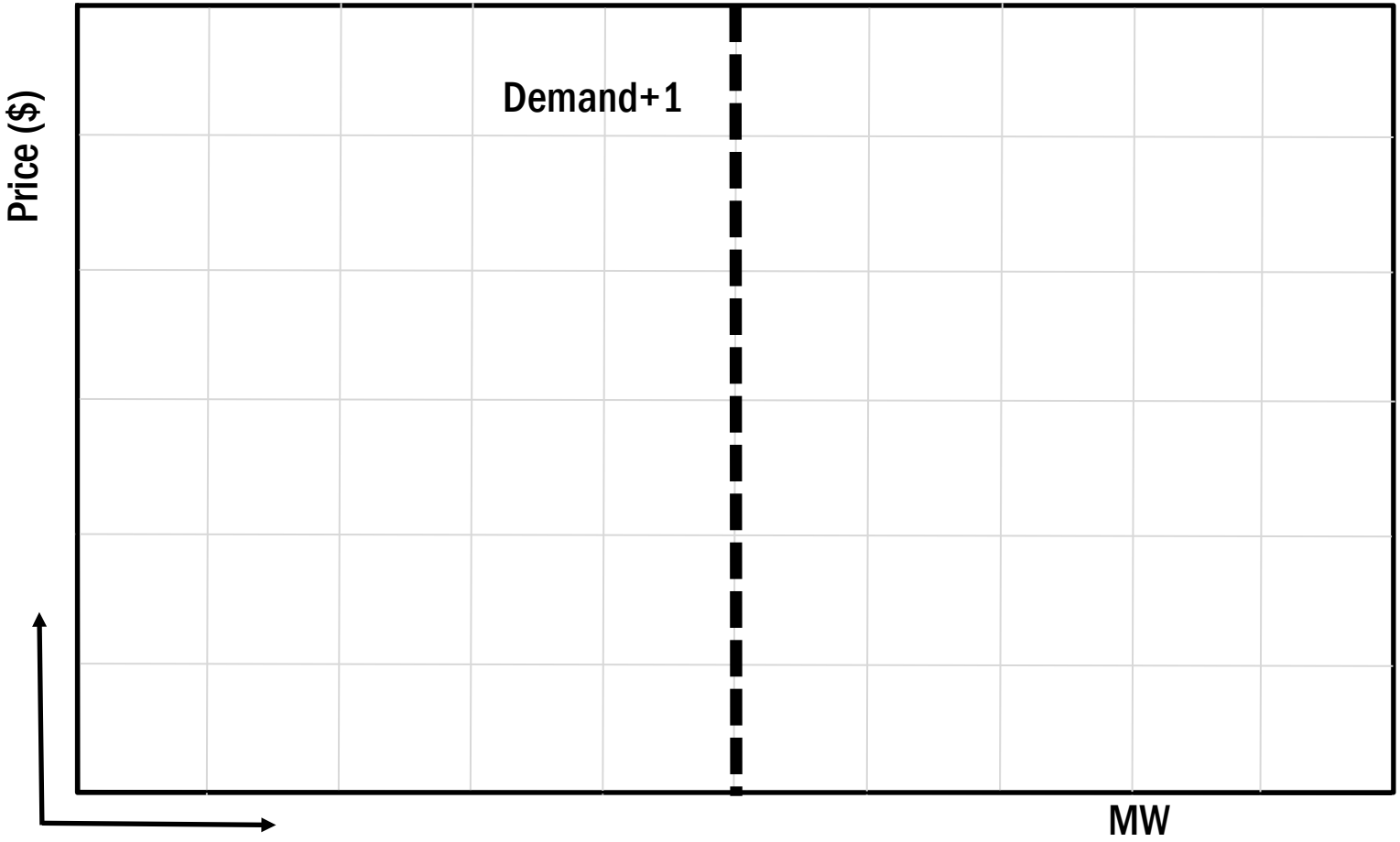
Determining the Marginal Energy Price



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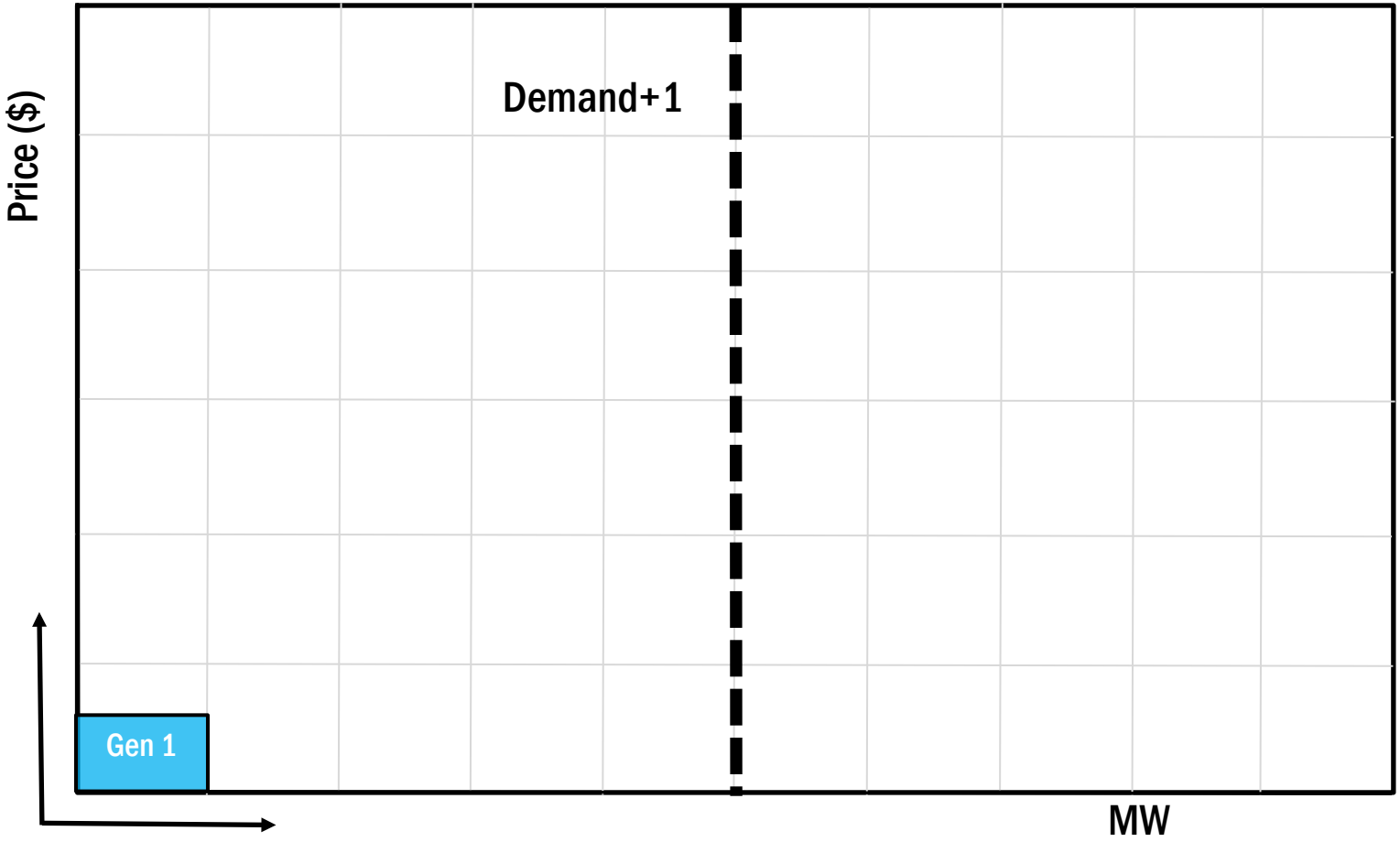
Determining the Marginal Energy Price



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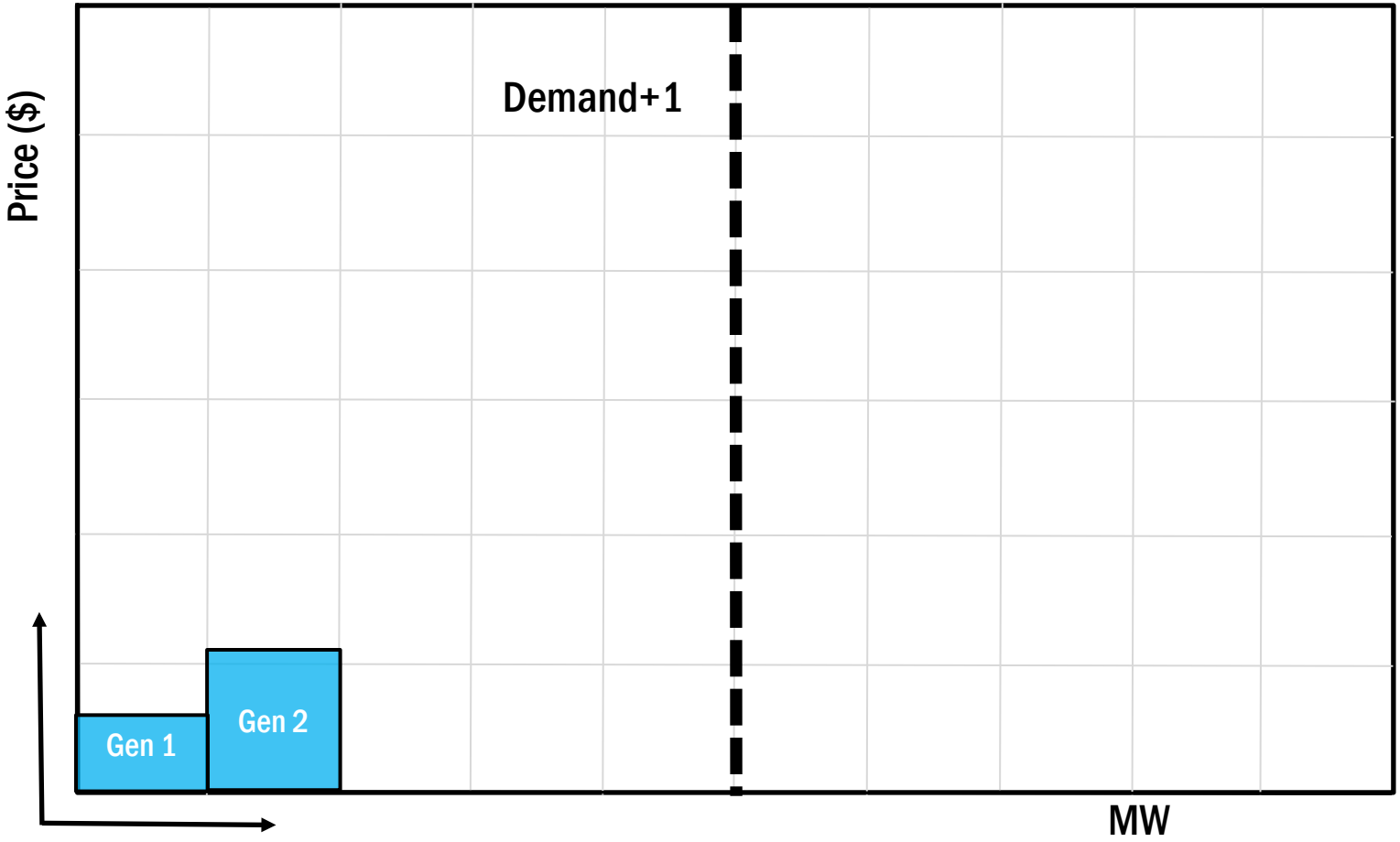
Determining the Marginal Energy Price



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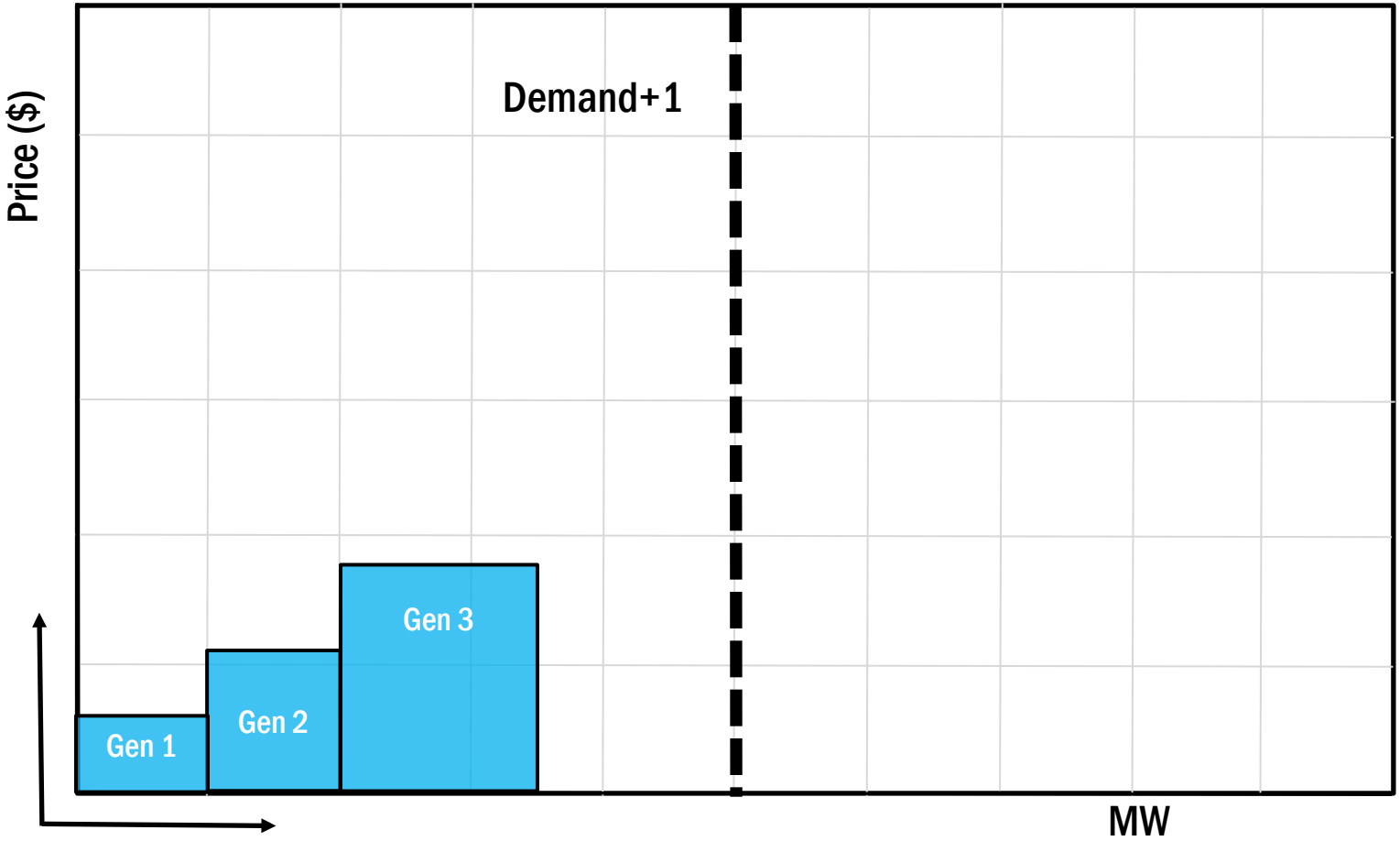
Determining the Marginal Energy Price



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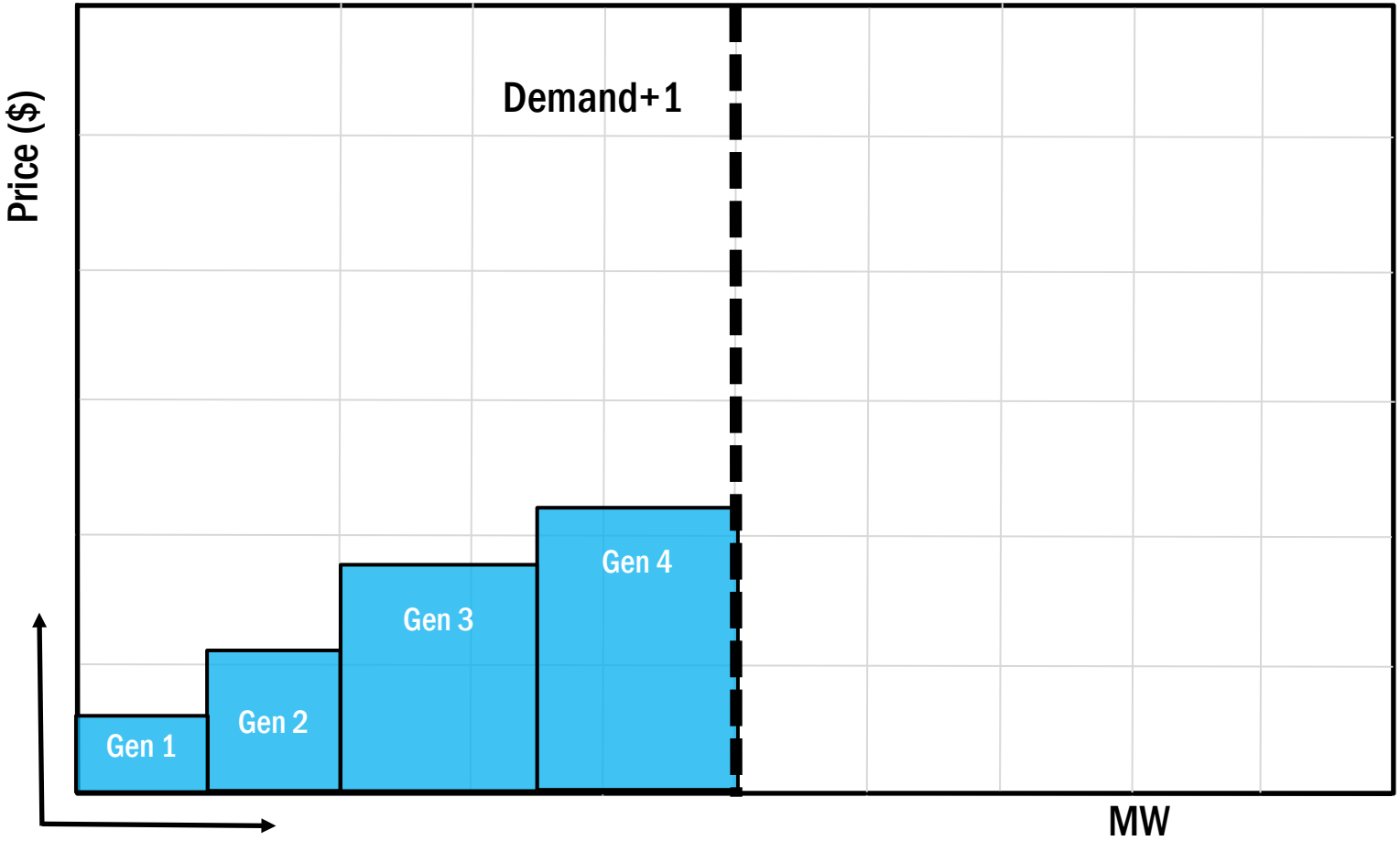

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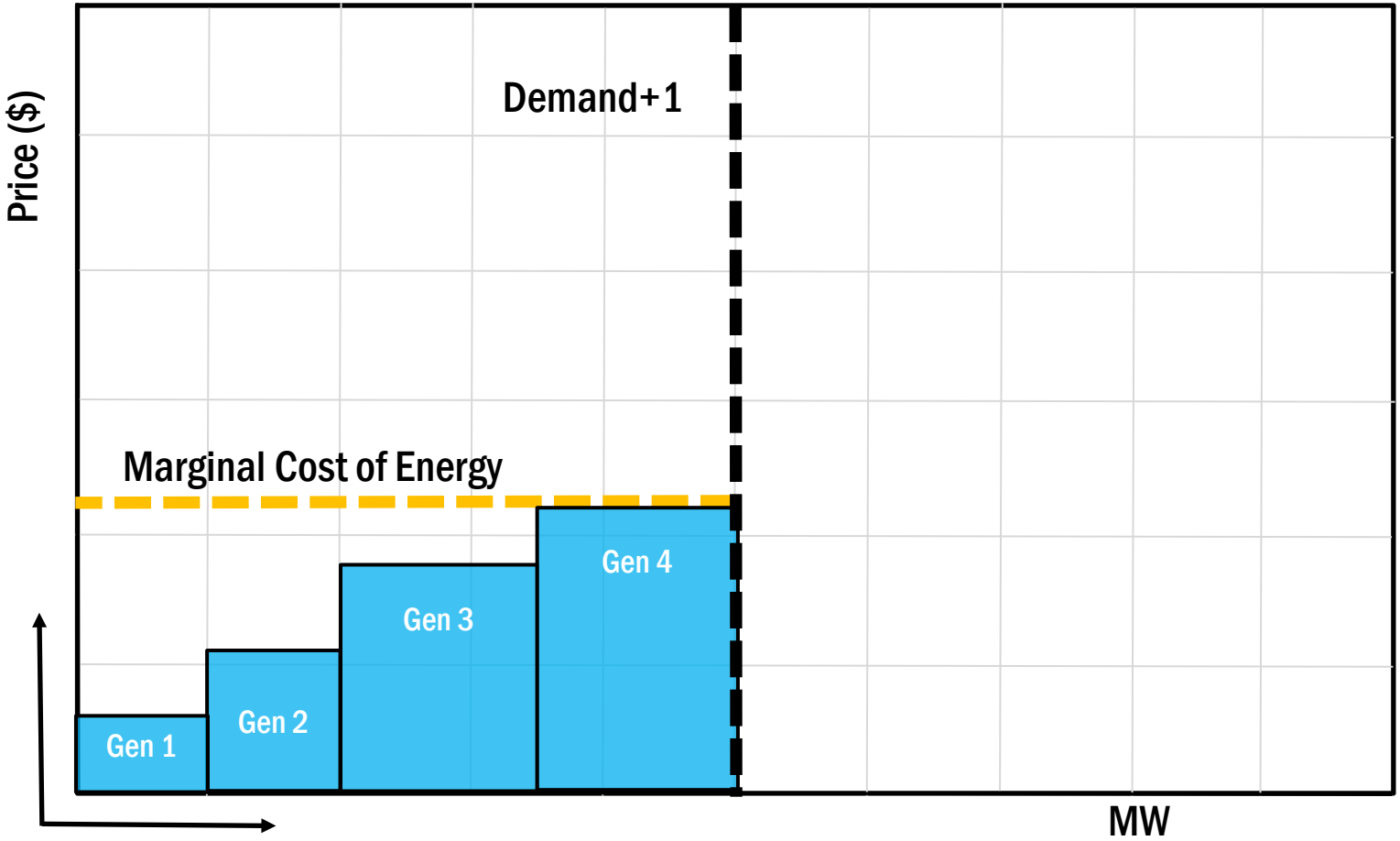
Determining the Marginal Energy Price



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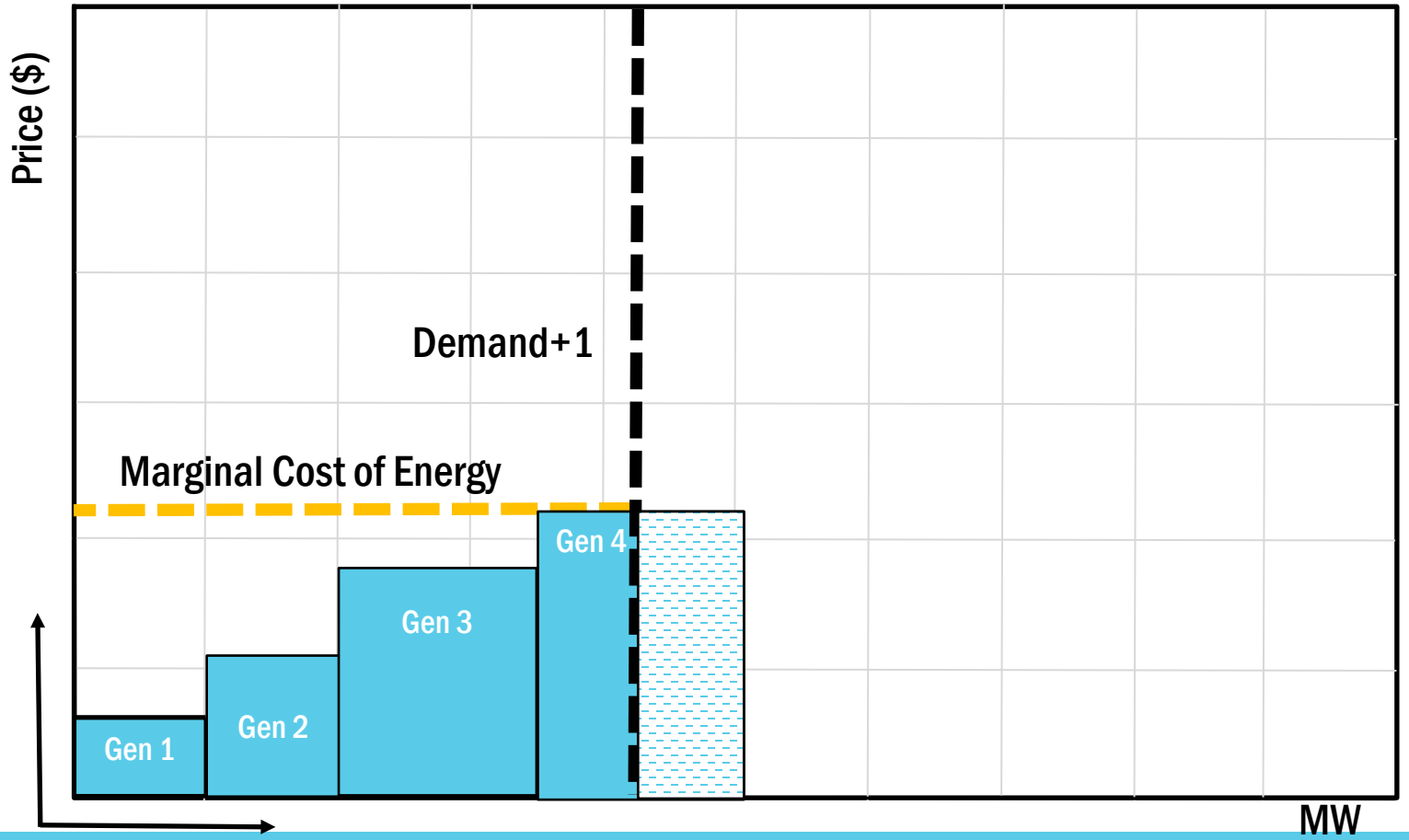

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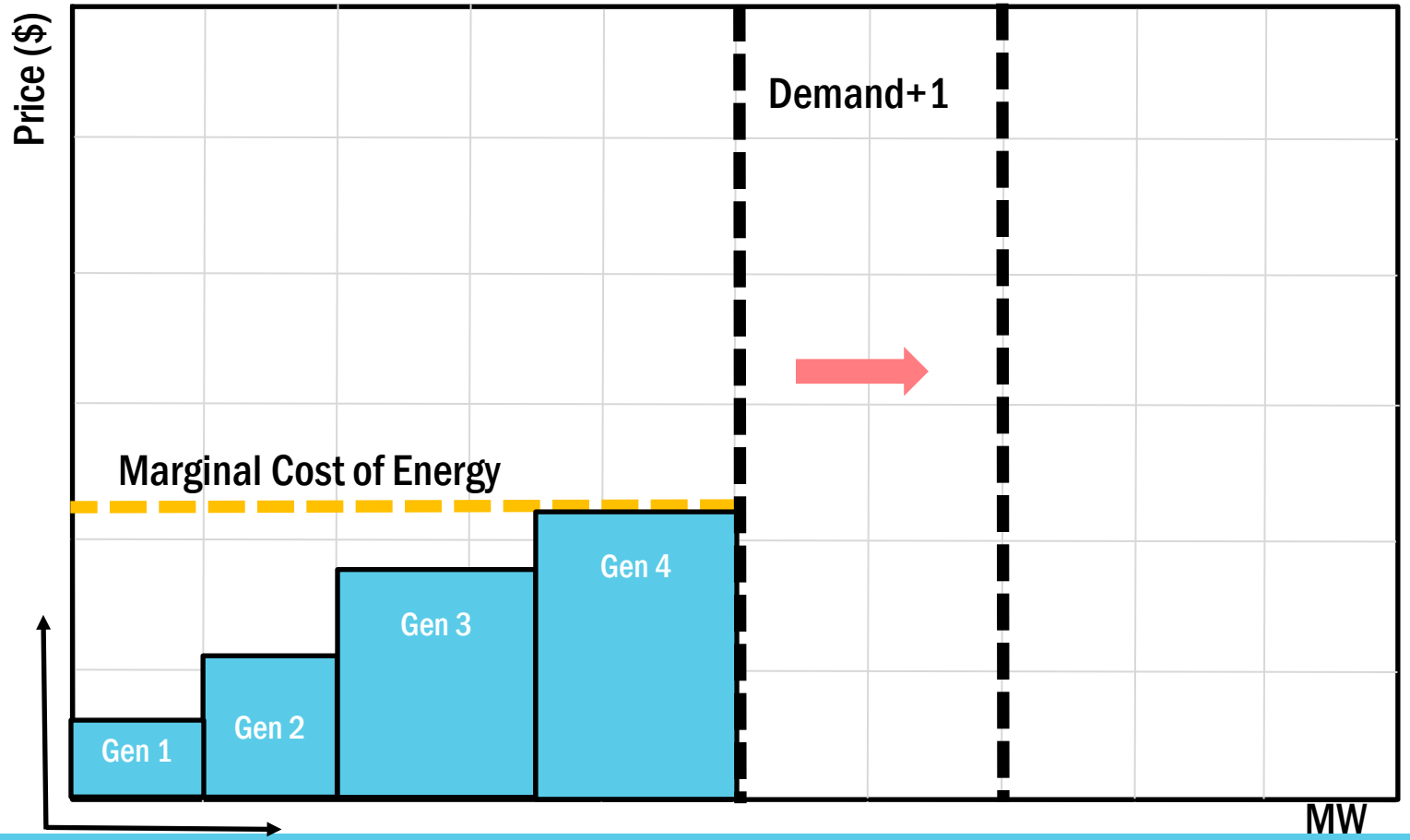

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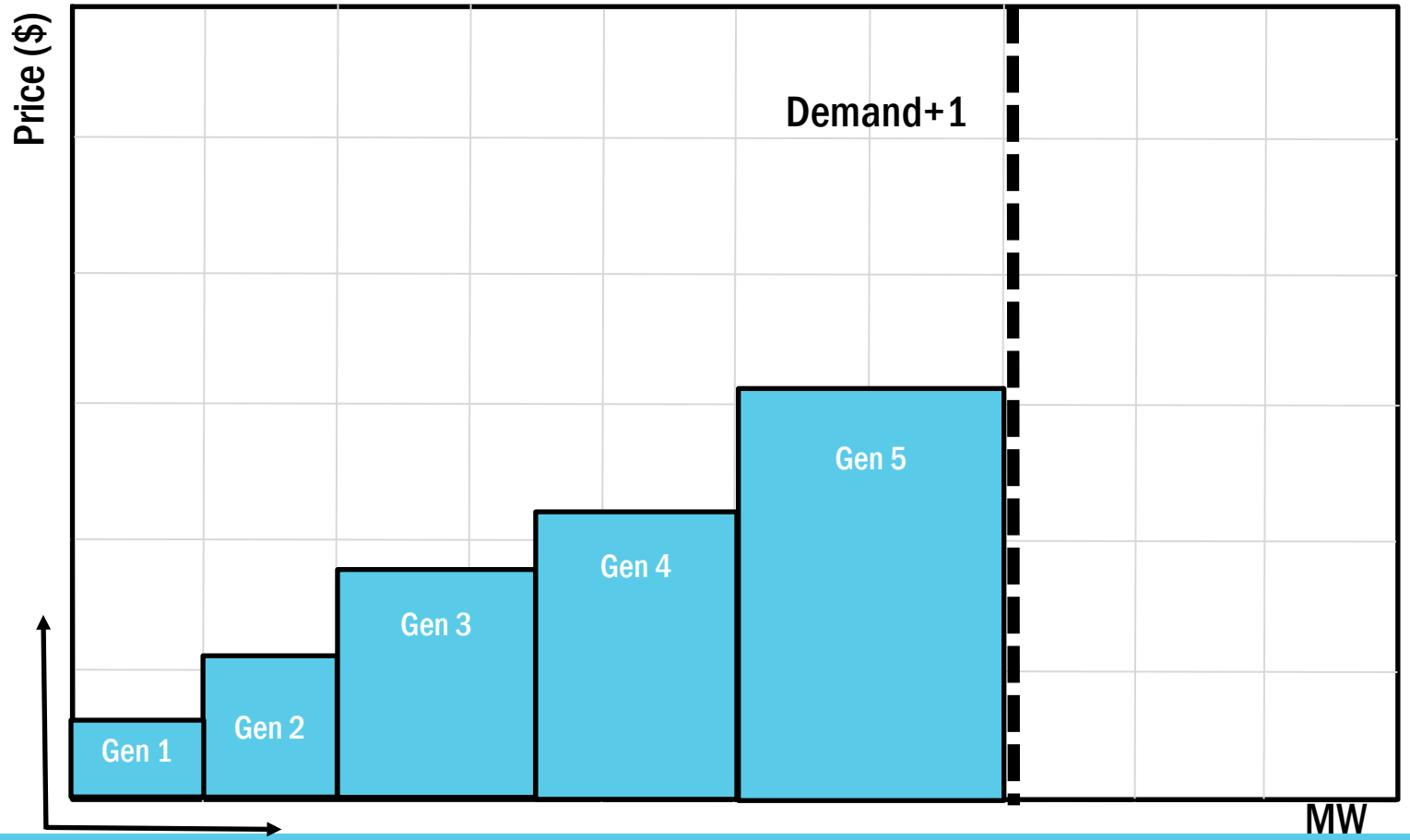

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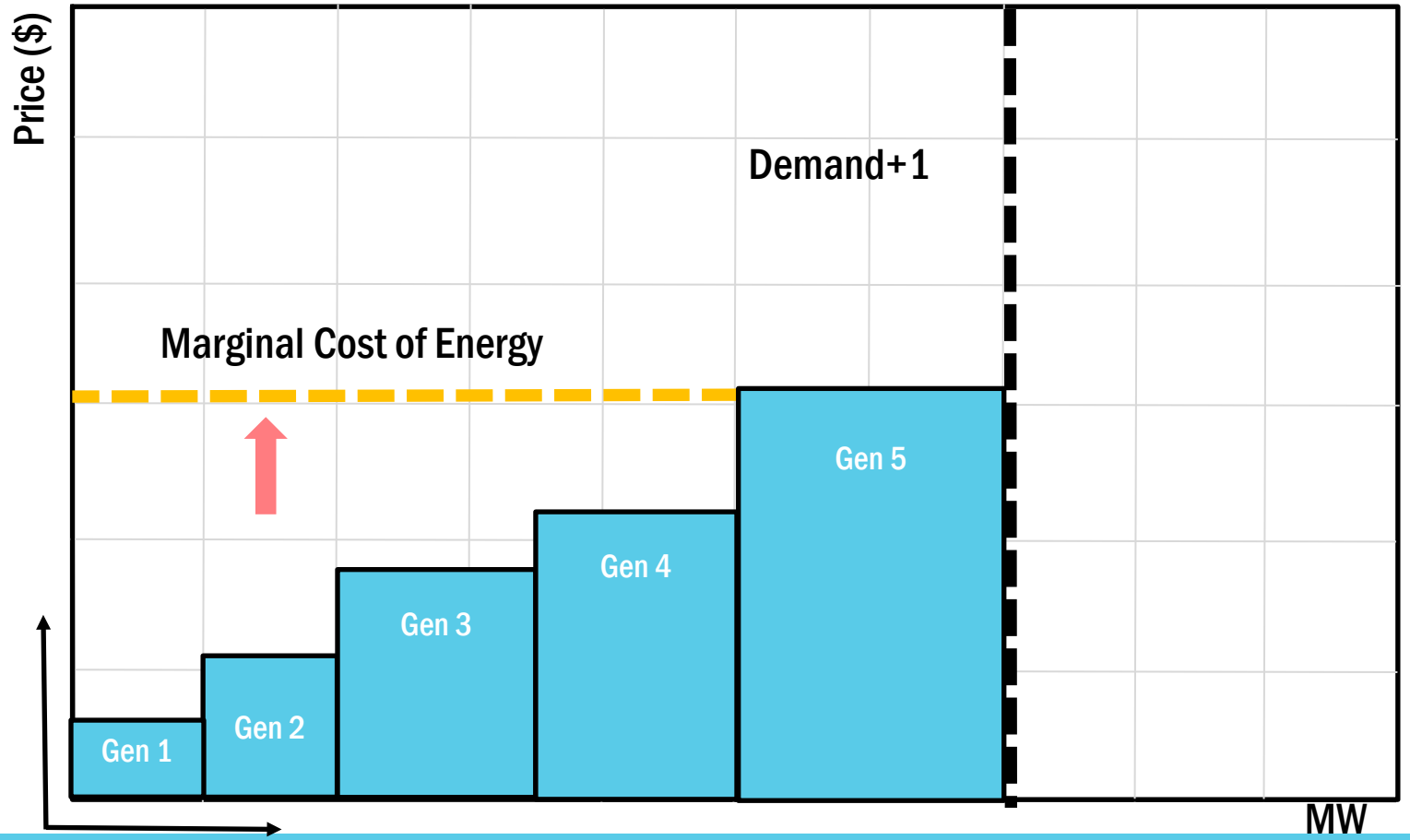

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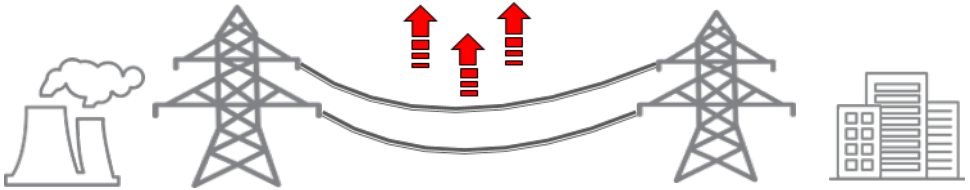
LBMP Components - Losses

- Marginal Loss Price Component
  - Some amount of generation will be lost along path to load due to heat dissipation
    - Transmission Losses
    - Approx. 2.5% of Energy is consumed by Losses in NYCA
  - Marginal Loss Component takes this into account
  - If Losses were zero, Loss $ Component would be zero as well



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LBMP Components - Losses

- Marginal Loss Price Component
  - Factors used to determine losses
    - Delivery Factor
    - Energy Price Component at NYISO Reference Bus
  - Delivery Factor
    - Impact on Overall System Losses (+/-) when power injected at a Specific Generator Bus

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LBMP Components - Losses

- Marginal Loss Price Component
  - Factors used to determine losses
    - Delivery Factor
    - Energy Price Component at NYISO Reference Bus
  - Delivery Factor
    - Impact on Overall System Losses (+/-) when power injected at a Specific Generator Bus

Delivery Factor	Impact on system Loss	Marginal Loss Price Component
Positive	Decreases System Loss	Positive
Negative	Increases System Loss	Negative

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LBMP Components - Losses

- Marginal Loss Price Component
  - For Detailed Information see OATT Attachment J or MST Attachment B
  - Market Participant User's Guide 3.3.1

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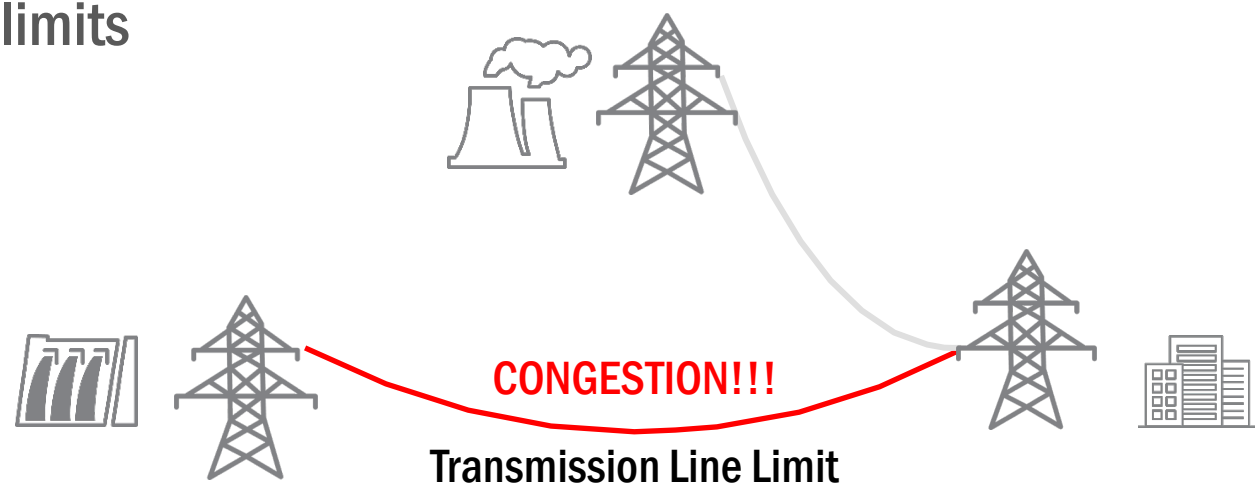
LBMP Components - Congestion

- Marginal Congestion Price Component
  - In some instances, dispatching least costly generation may exceed line limitations
  - More costly units may subsequently be dispatched to avoid exceeding those limits



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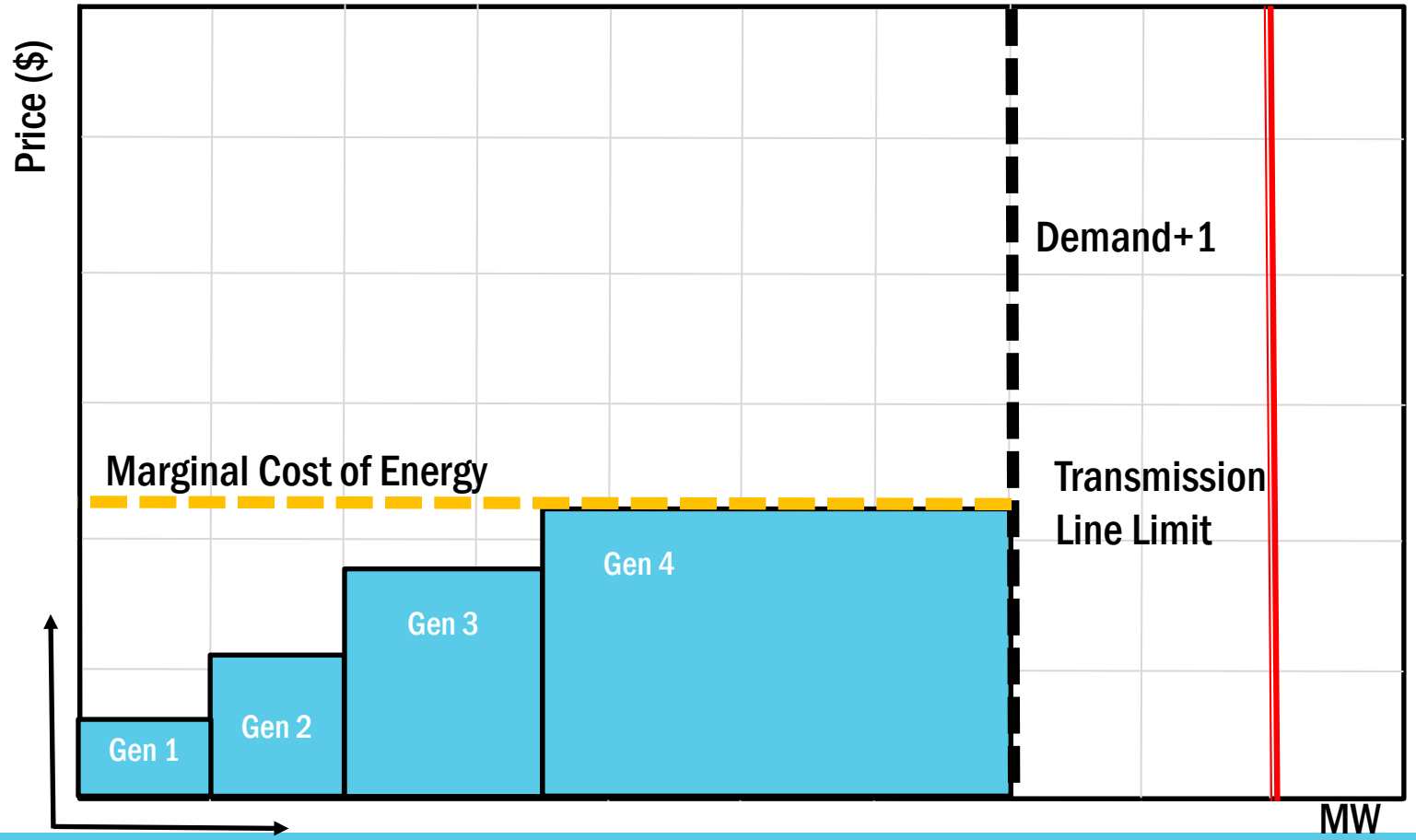
Determining the Marginal Congestion Price



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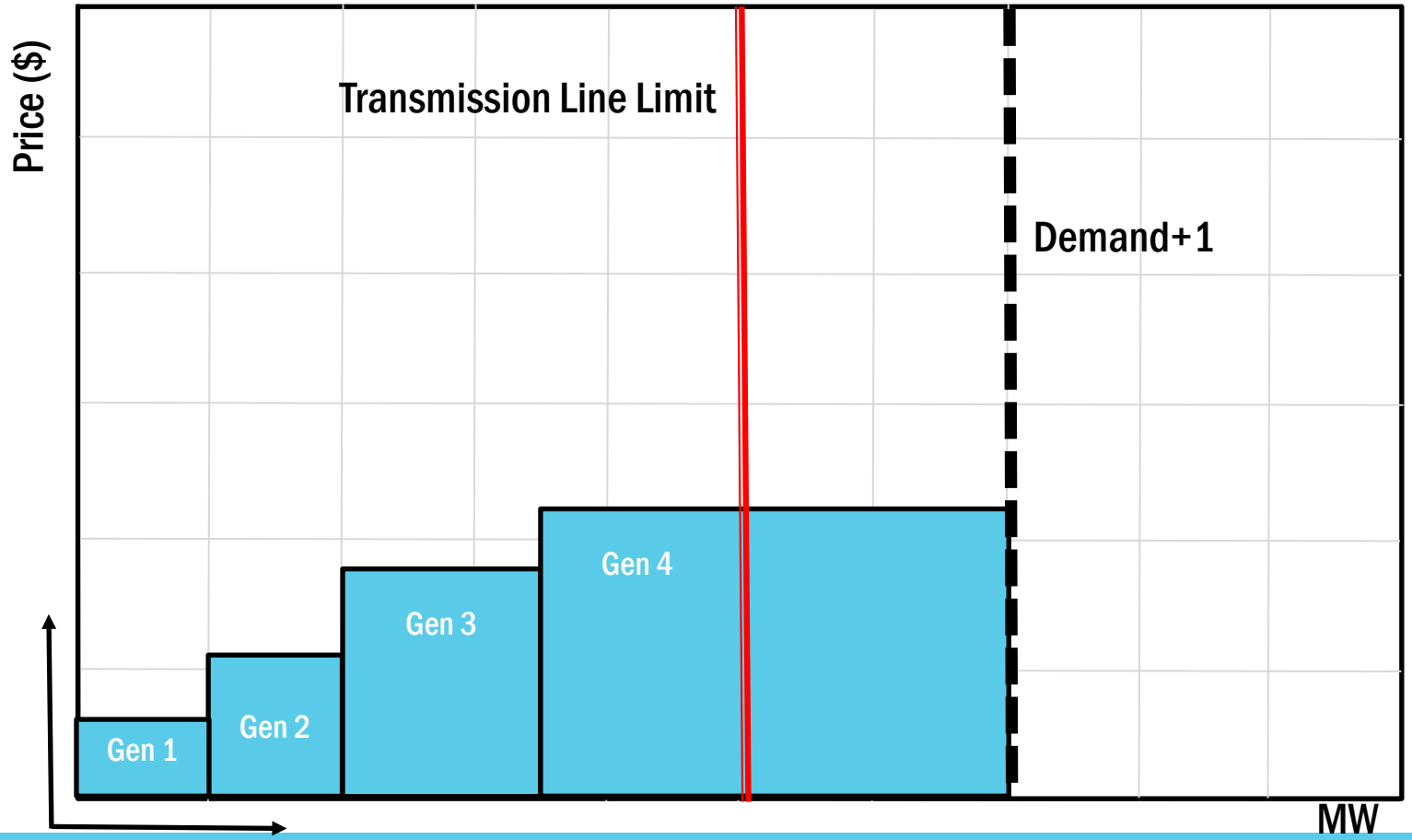
Determining the Marginal Congestion Price

New York ISO



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Determining the Marginal Congestion Price

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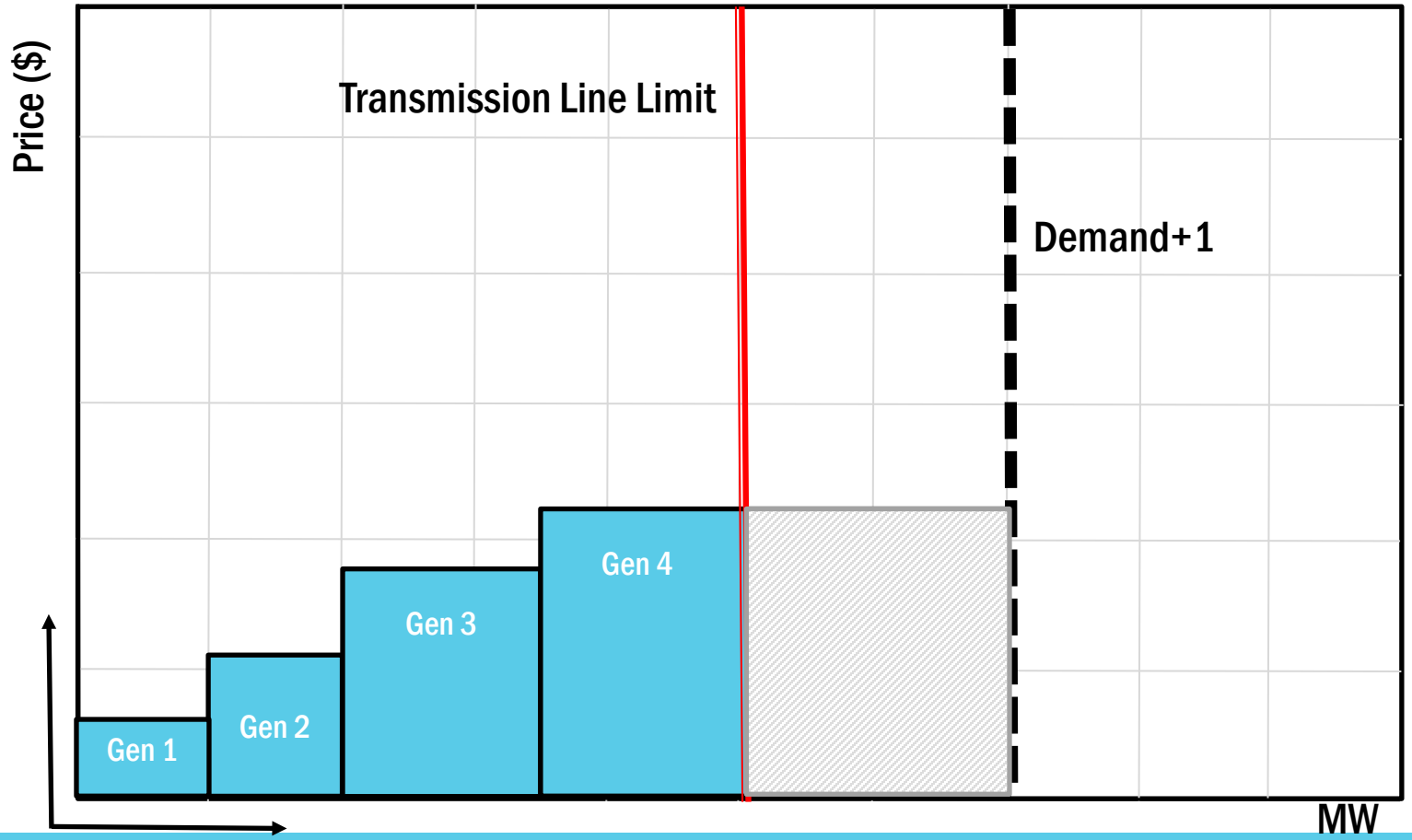

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Determining the Marginal Congestion Price

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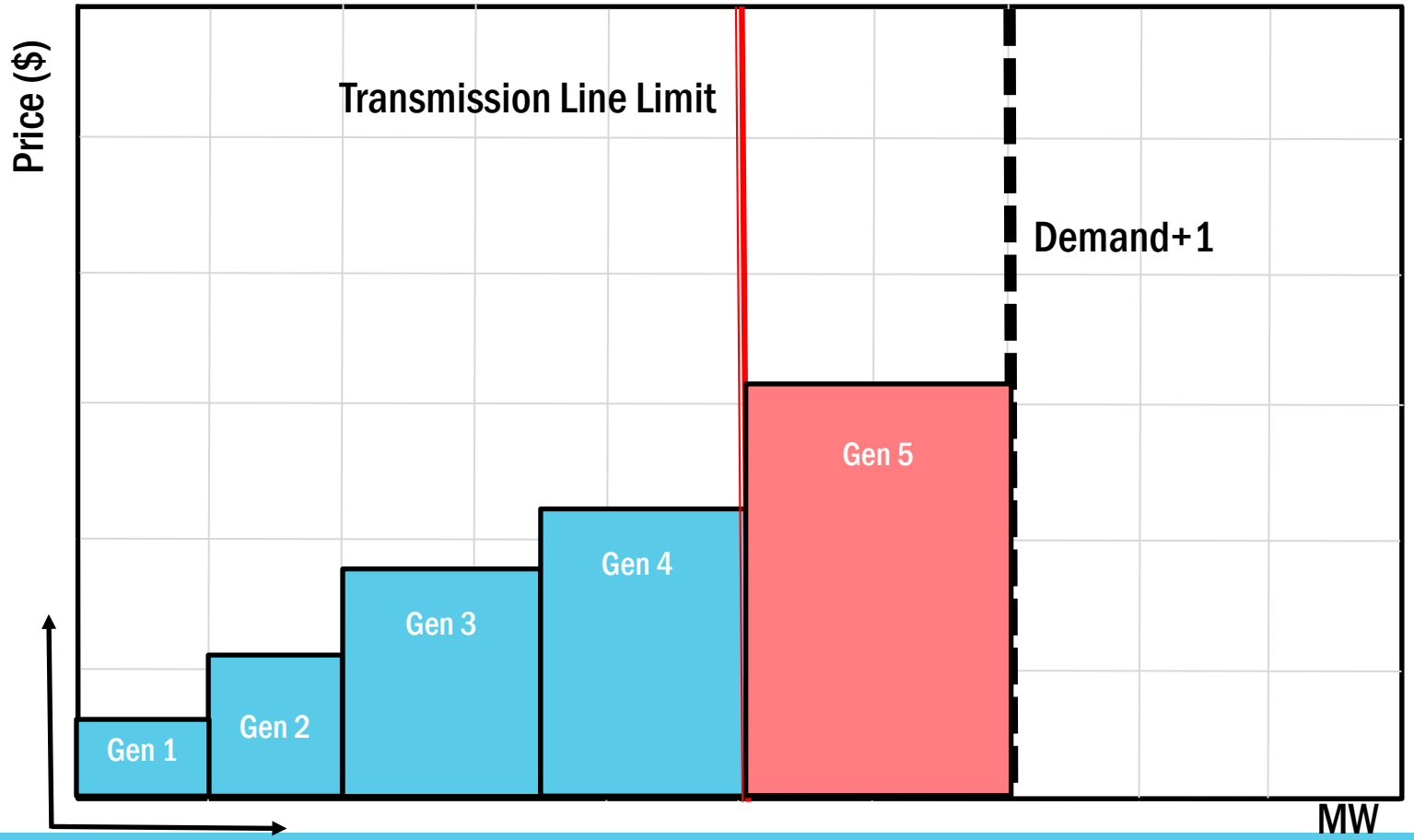

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Determining the Marginal Congestion Price

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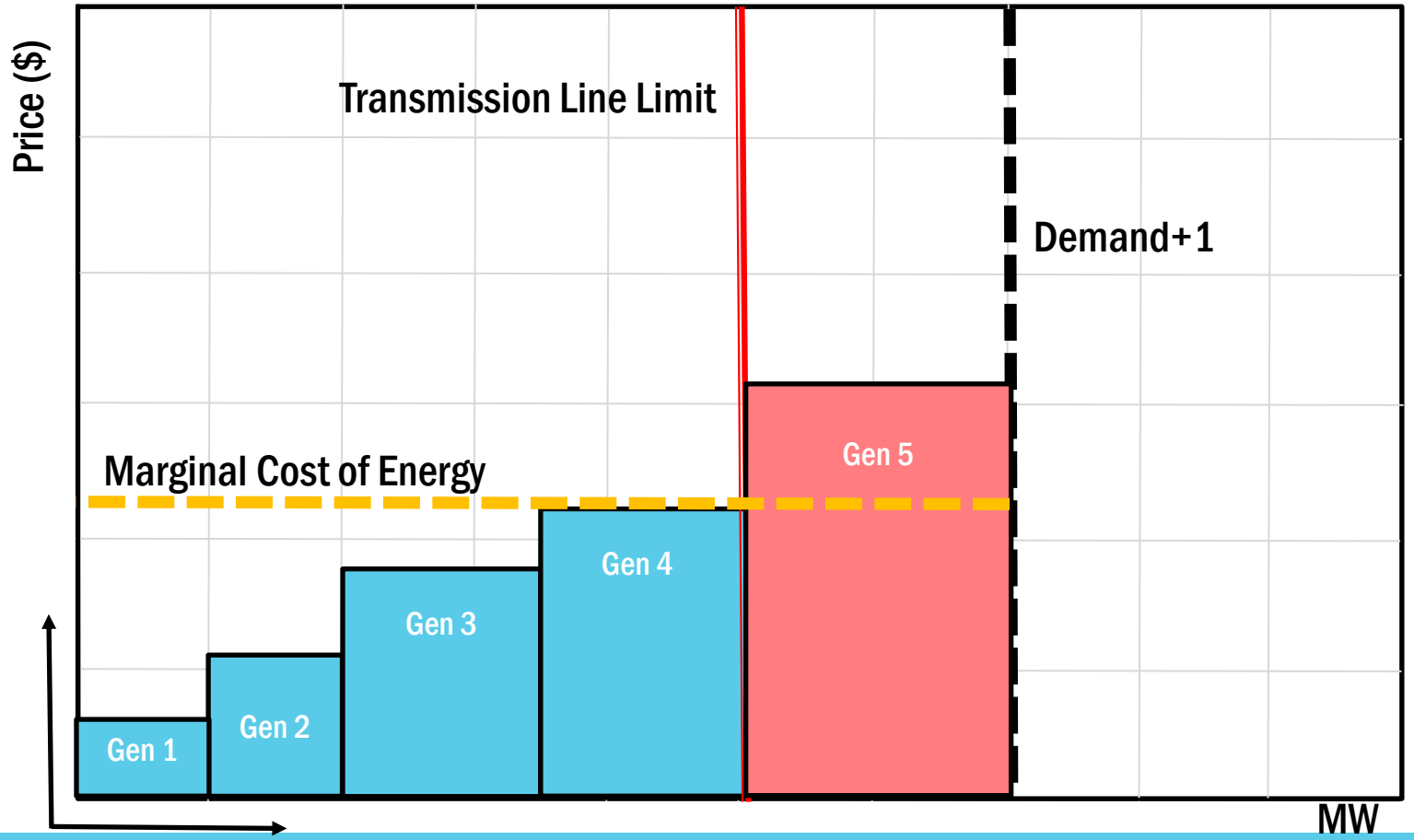

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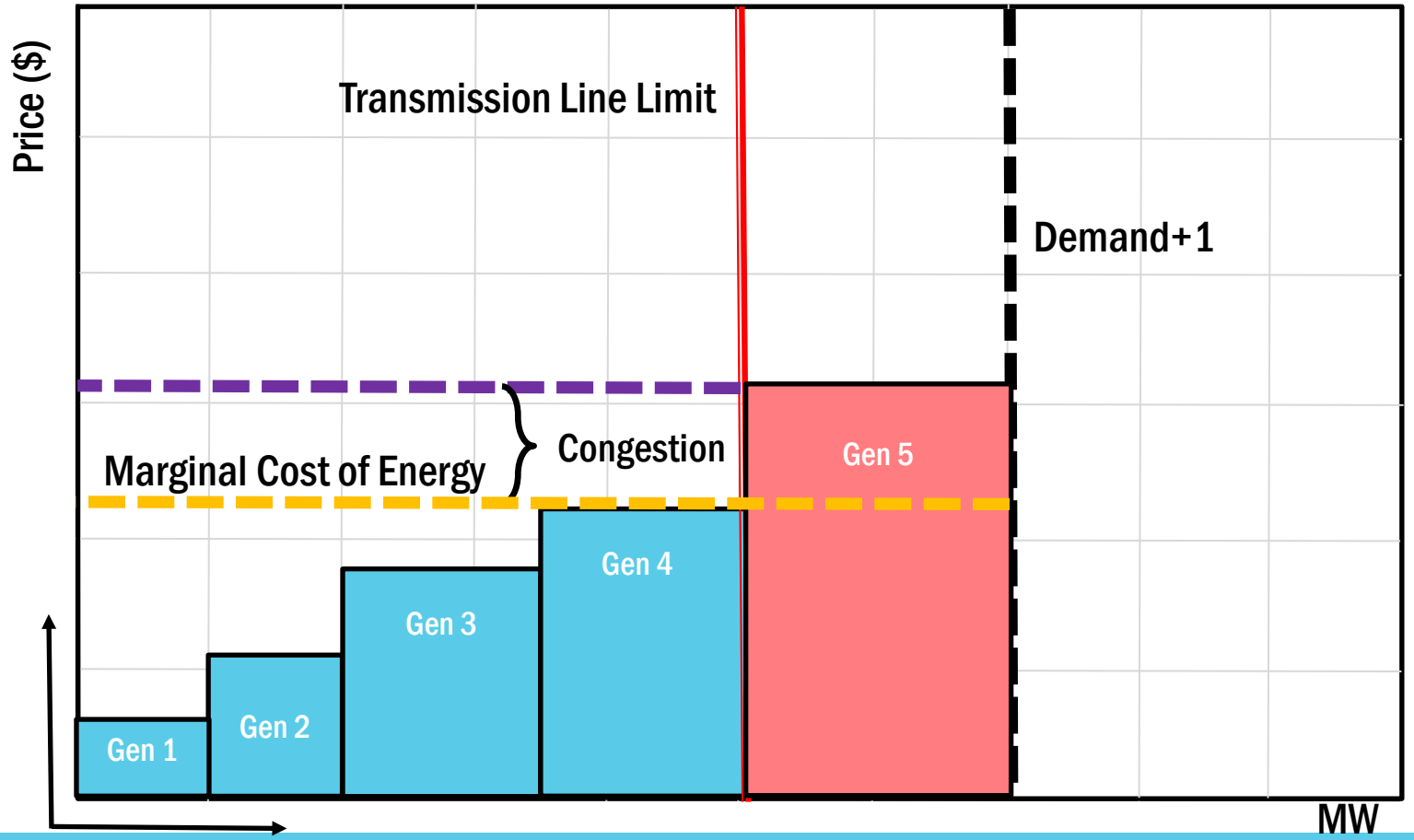
Determining the Marginal Congestion Price



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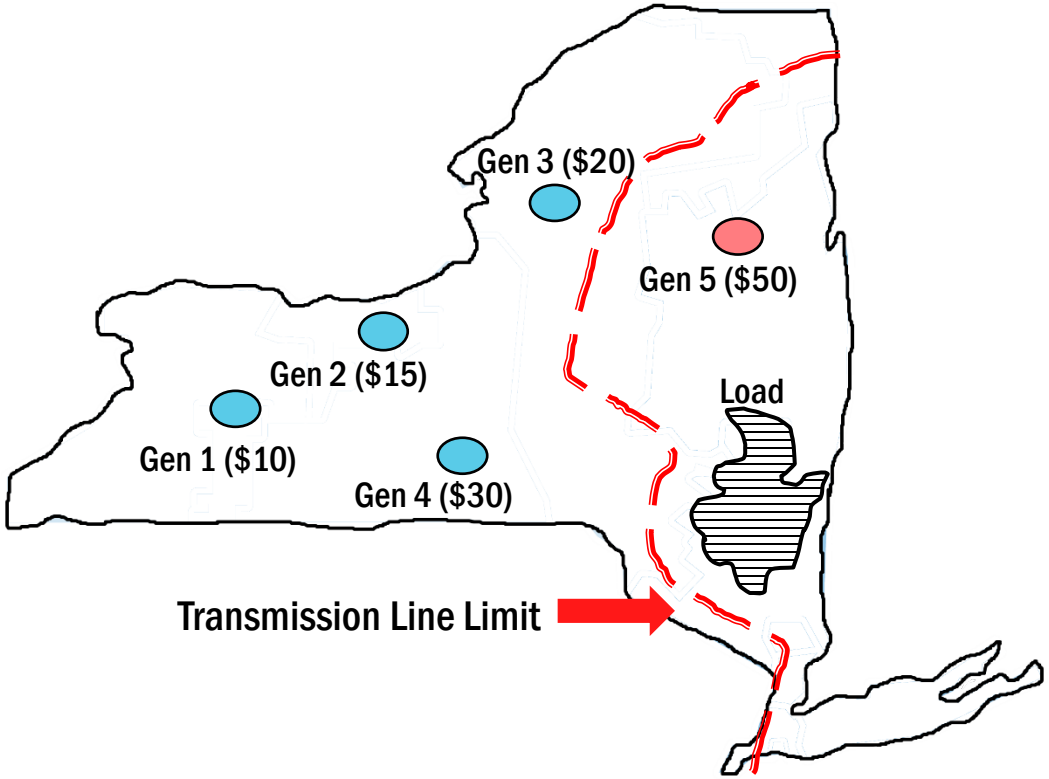
LBMP - Congestion

- Marginal Congestion Price Component
  - Difference between 2 marginal prices creates congestion component



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LBMP Components

- Three Components of LBMP
  - Marginal Energy Price Component
  - Marginal Loss Price Component
  - Marginal Congestion Price Component

LBMP = Energy + Loss - Congestion

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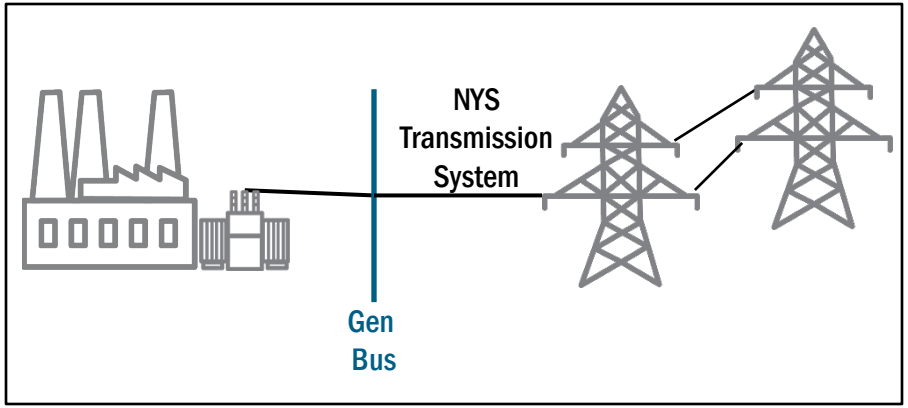
Generators – Gen Bus LBMP

- LBMP for Generators
  - Based on Generator Bus
  - LBMP calculated at Bus where Generator injects power



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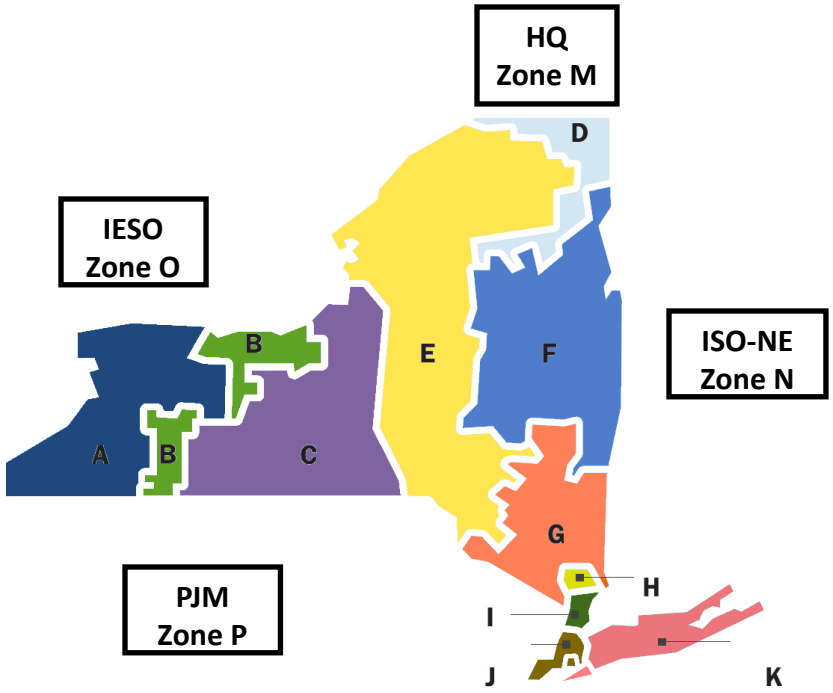
Load Serving Entity – Zonal LBMP

- LBMP for Load
  - Based on Zone where Load is Located
  - One Zonal LBMP for entire Zone
  - Load Weighted Average



NYCA Load Zones		
A- West	E- Mohawk Valley	I- Dunwoodie
B- Genesee	F- Capital	J- NYC
C- Central	G- Hudson Valley	K- Long Island
D- North	H- Millwood	

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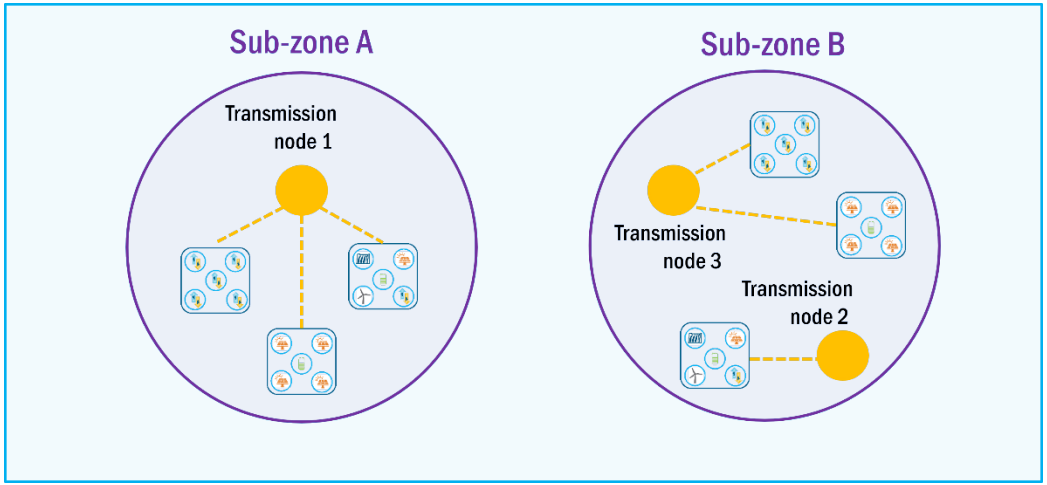
Aggregations – Transmission Node LBMP

- LBMP for Aggregations
  - Based on Transmission Node
    - Transmission Nodes reflect a collection of designated load buses on which individual DER are located and may participate together in an Aggregation



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Example 1: Energy Only
No Losses and No Congestion

Total Load = 150 MW

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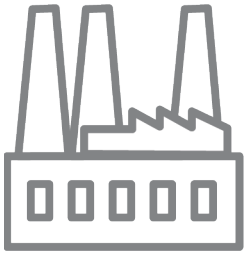
Example 1: Energy Only

Gen '*Power Up*'
100 MW, Bid @$20/MW

Gen '*Full Steam*'
150 MW, Bid @$35/MW



Gen '*Energy*'
100 MW, Bid @$30/MW

Gen '*Lights On*'
200 MW, Bid @$40/MW

Limit
150 MW

West Zone
Load A
30 MW

Total Load
150 MW

East Zone
Load B
120 MW

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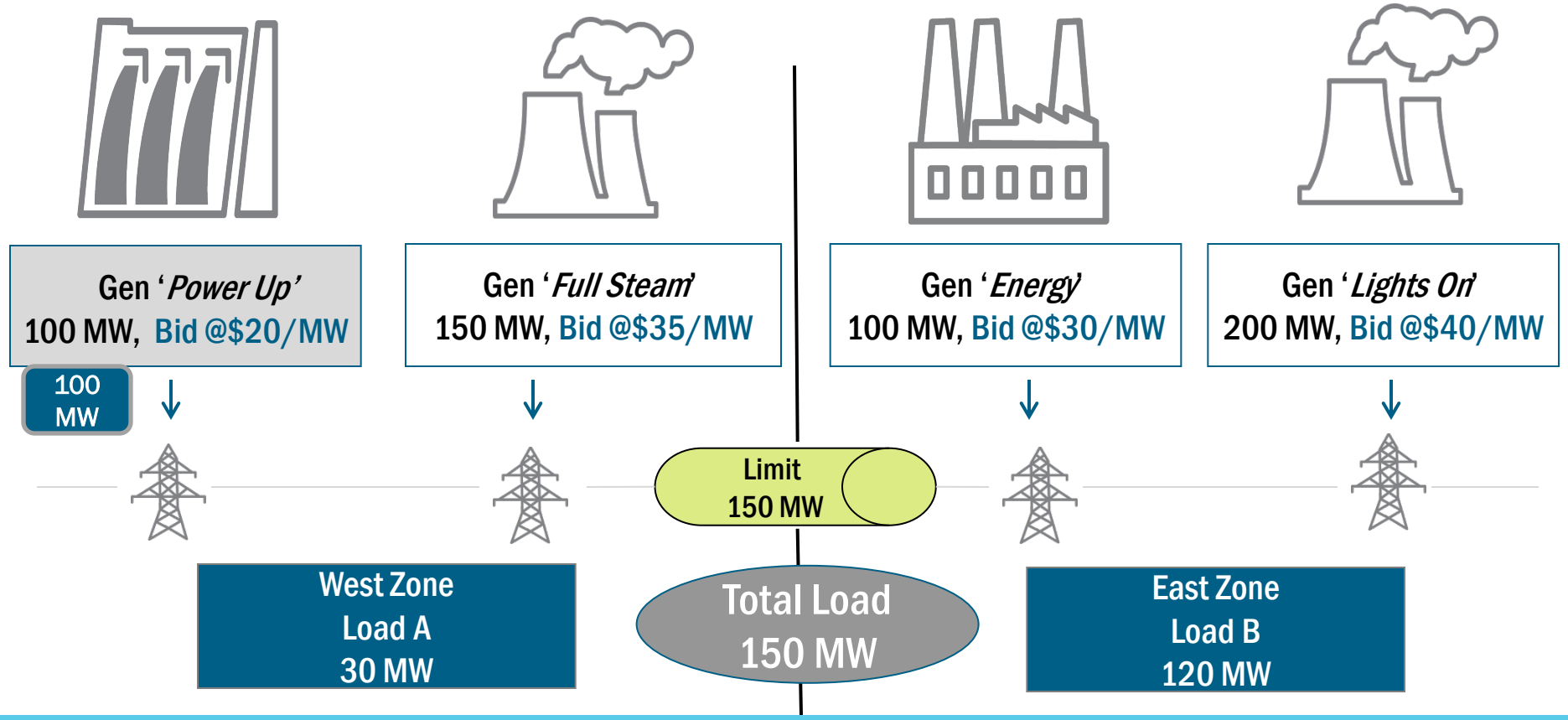
Example 1: Energy Only



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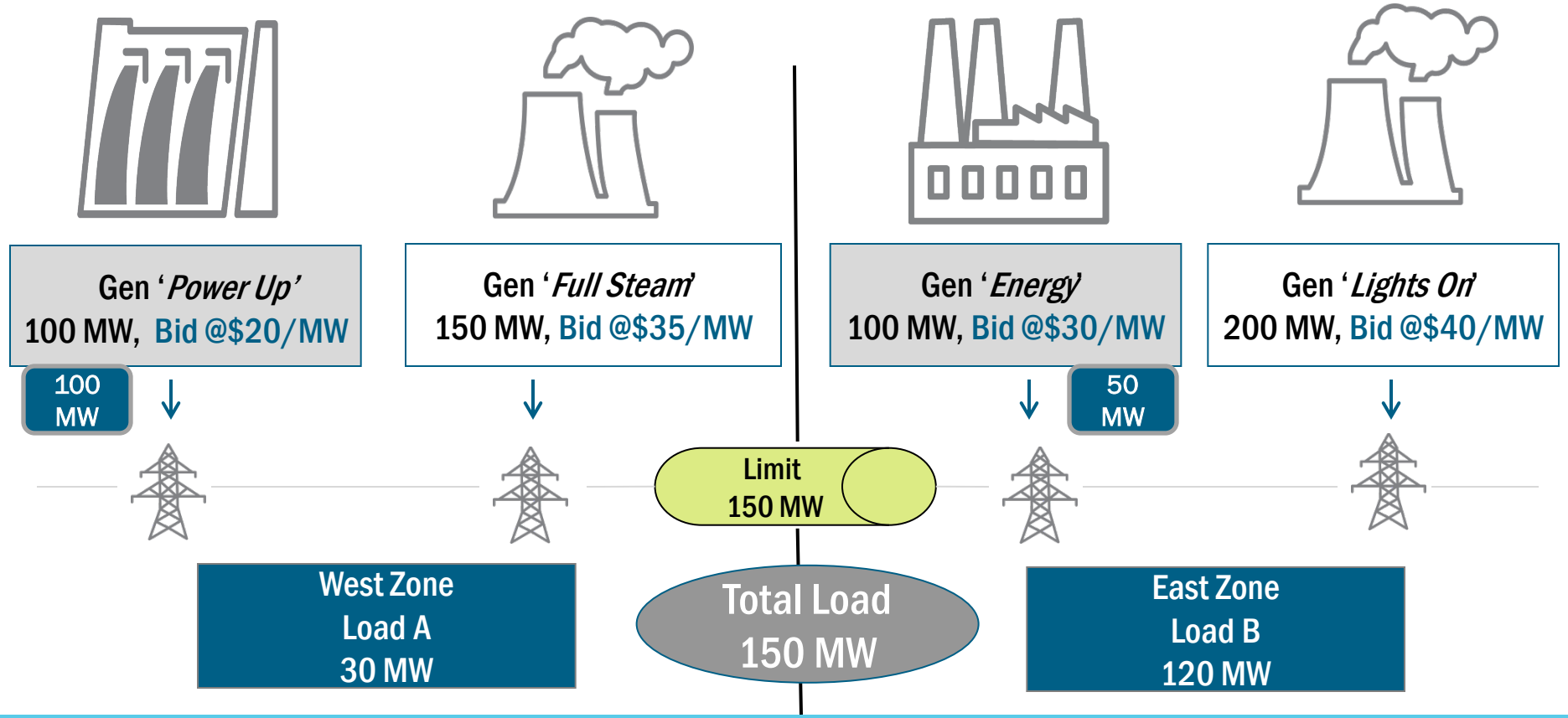

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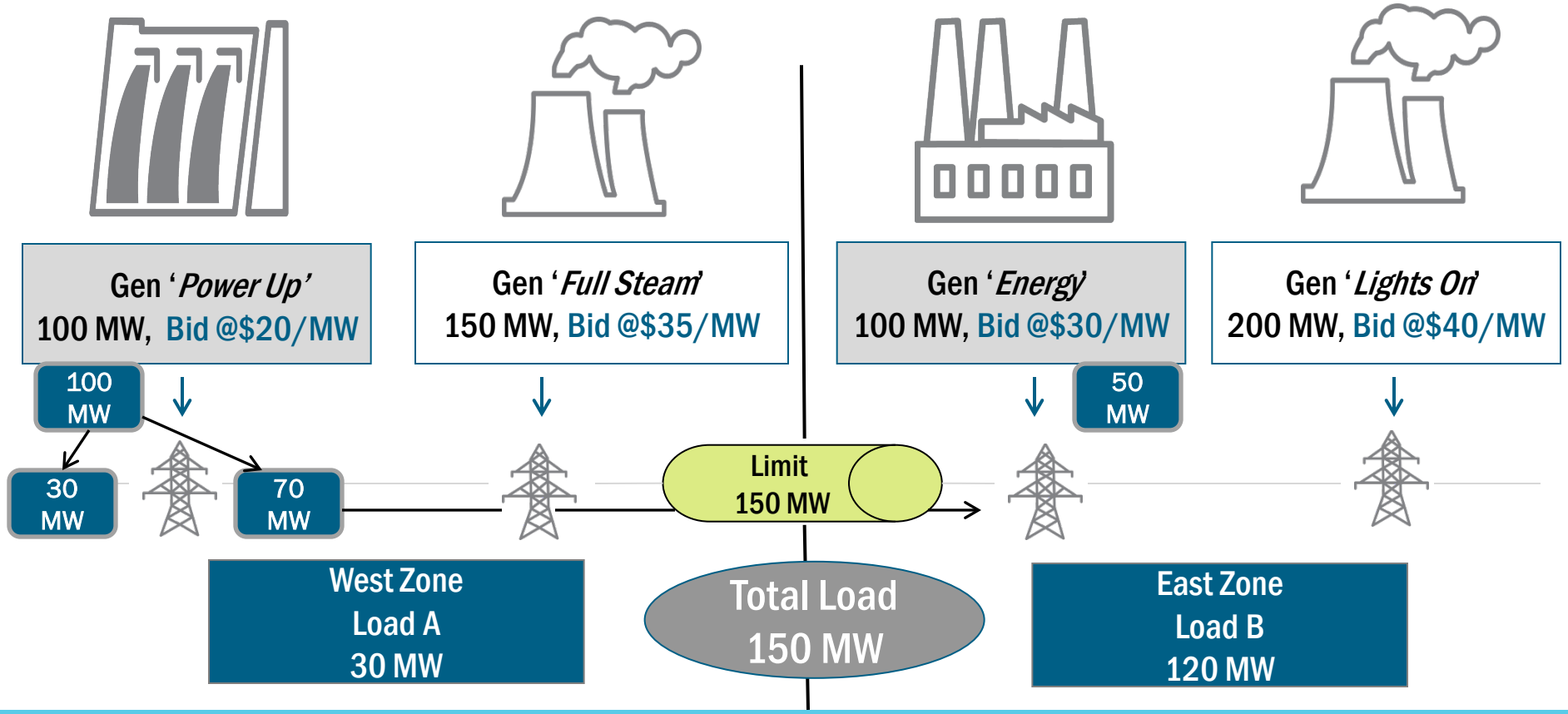

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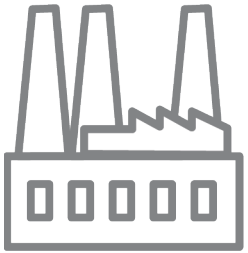
Example 1: Energy Only - Results

Gen '*Power Up*'
100 MW, Bid @$20/MW

Gen '*Full Steam*'
150 MW, Bid @$35/MW



Gen '*Energy*'
100 MW, Bid @$30/MW

Gen '*Lights On*'
200 MW, Bid @$40/MW

Energy	$30.00
Loss	$0.00
Congestion	-$0.00
LBMP	$30.00

West Zone
Load A
30 MW

West Zone LBMP $30/MW

Limit
150 MW

Total Load
150 MW

East Zone
Load B
120 MW

East Zone LBMP $30/MW

Energy	$30.00
Loss	$0.00
Congestion	-$0.00
LBMP	$30.00

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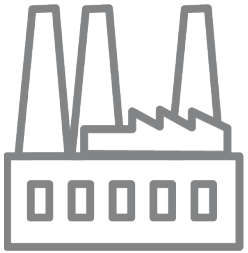
Example 1: Energy Only - Results

Gen '*Power Up*',100 MW
Bid $20, Paid $30

Gen '*Full Steam*' ,150 MW
Bid $35, Paid $0



Gen '*Energy*' ,100 MW
Bid $30, Paid $30

Gen '*Lights On*', 200 MW
Bid $40, Paid $0

West Zone

East Zone

Generators receive $30/MW (LBMP)

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Example 1: Energy Only - Results

Loads Charged $30/MW (LBMP)

West Zone
Load A
30 MW

East Zone
Load B
120 MW

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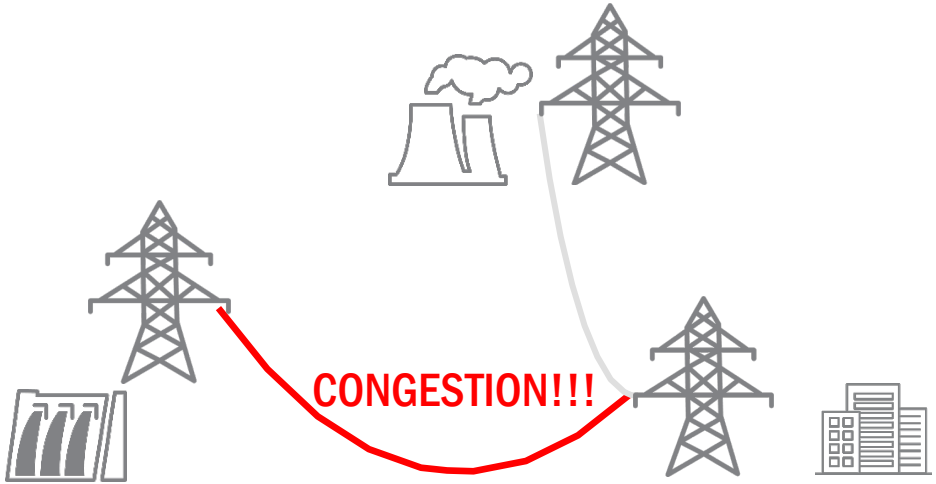
Congestion

- Congestion occurs when the Power flow reaches the Transmission Limit
- To maintain efficient and reliable Transmission system
  - Transmission limits cannot be exceeded
  - When Transmission limits reached, generators from different buses are dispatched to meet load
- When there is congestion, LBMPs can differ between buses



Transmission Line Limit

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Contributing Congestion Factors

- Generator Derates
- Line Outages
- Transaction Curtailments
- TSA – Severe Weather Conditions
- Reserve Shortage
- Alert State
- OOM & SRE Request
- Forecast Load vs. Actual RT Load

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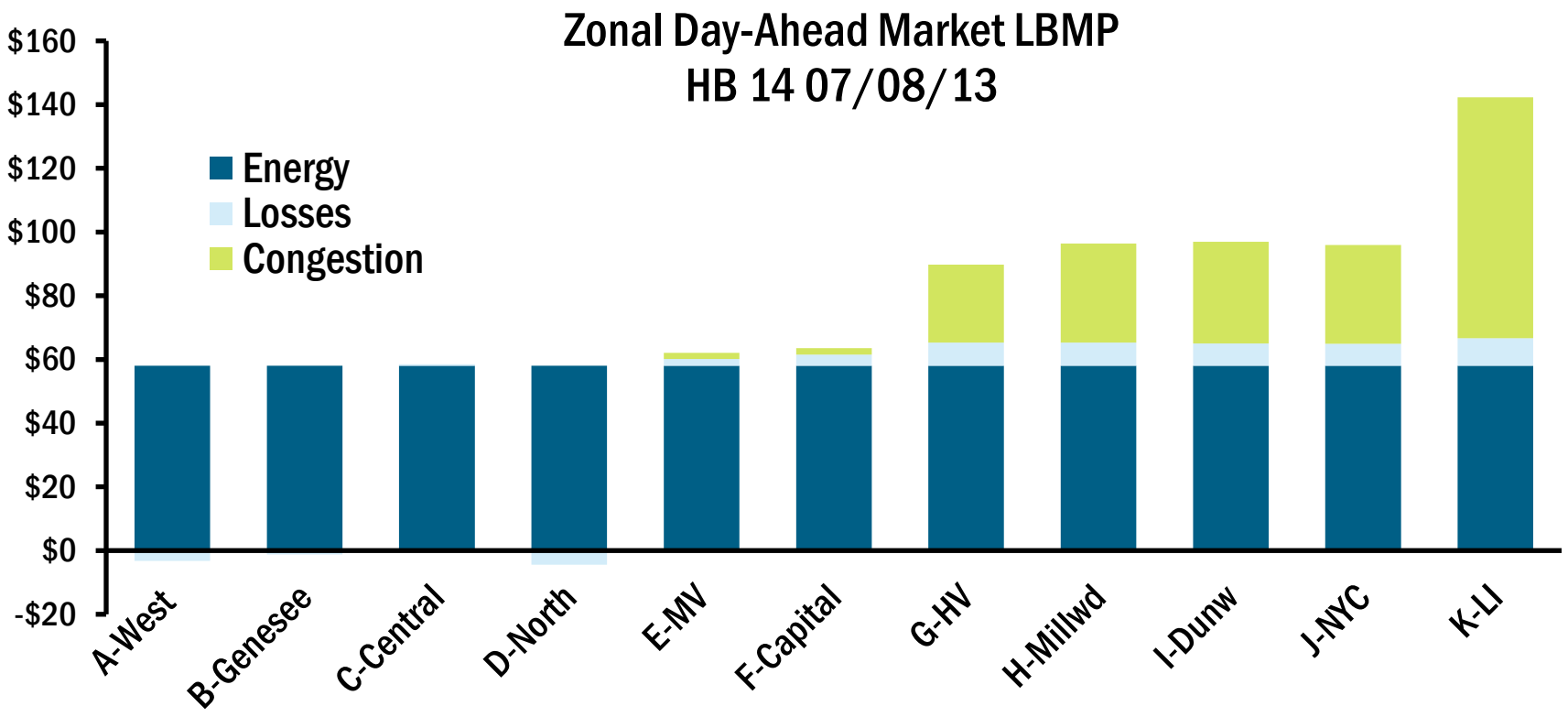
Day Ahead LBMP- Zonal pattern for 1 hour



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Example 2: Energy and Congestion, No Losses

Total Load = 300 MW

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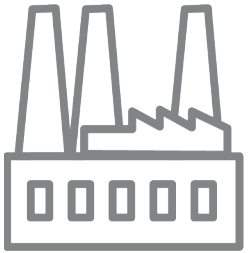
Example 2: Energy and Congestion

Gen '*Power Up*'
110 MW, Bid @$40/MW

Gen '*Full Steam*'
100 MW, Bid @$30/MW



Gen '*Energy*'
100 MW, Bid @$35/MW

Gen '*Lights On*'
150 MW, Bid @$50/MW

Limit
150 MW

West Zone
Load A
20 MW

Total Load
300 MW

East Zone
Load B
280 MW

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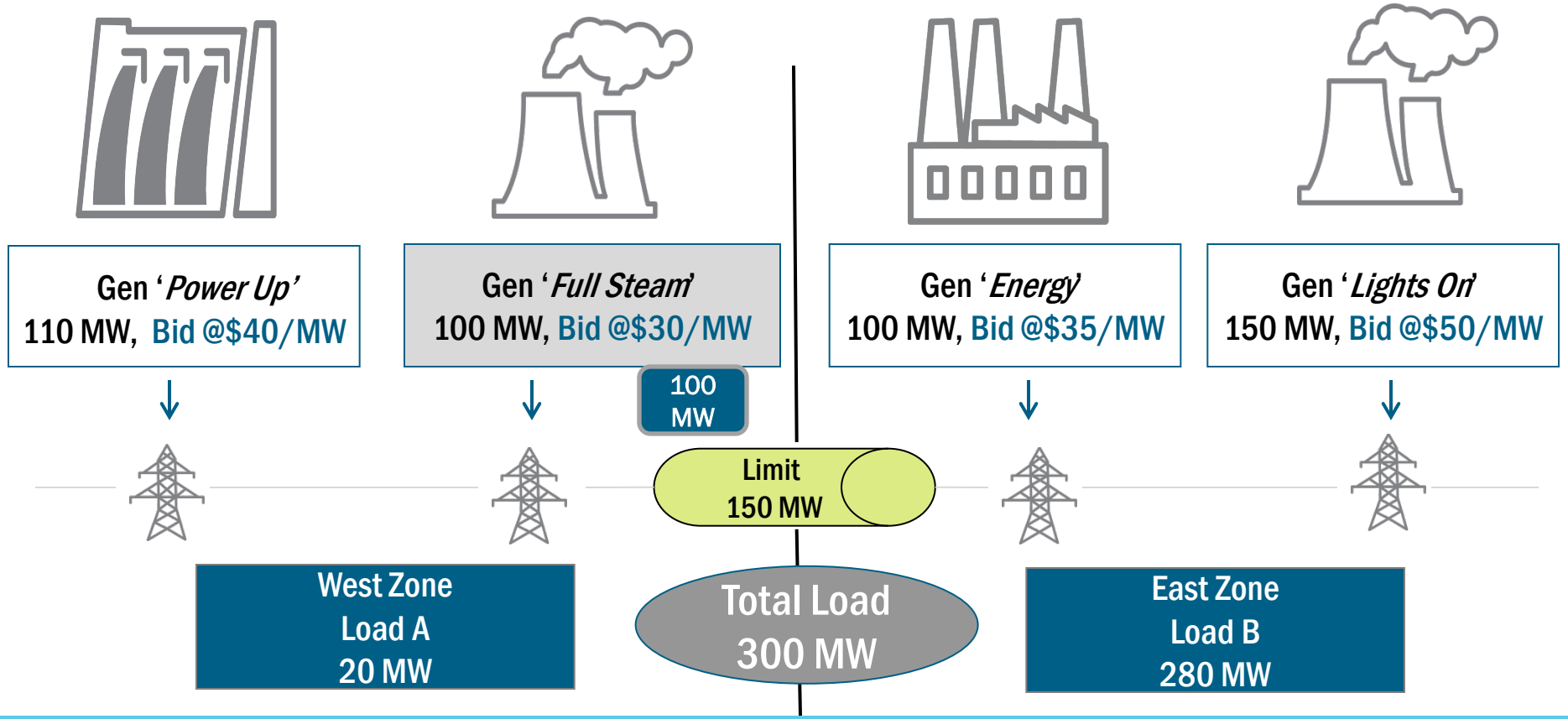
Example 2: Energy and Congestion



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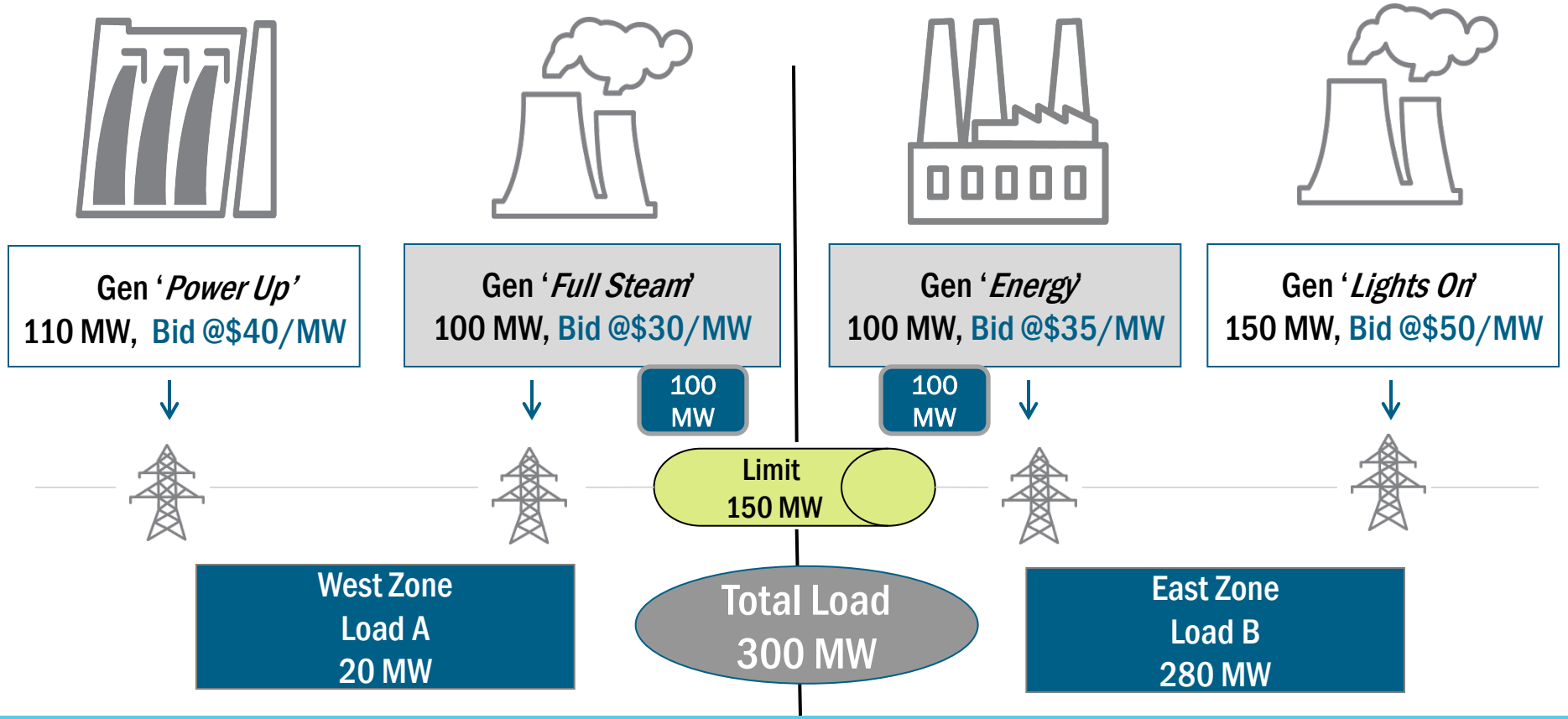

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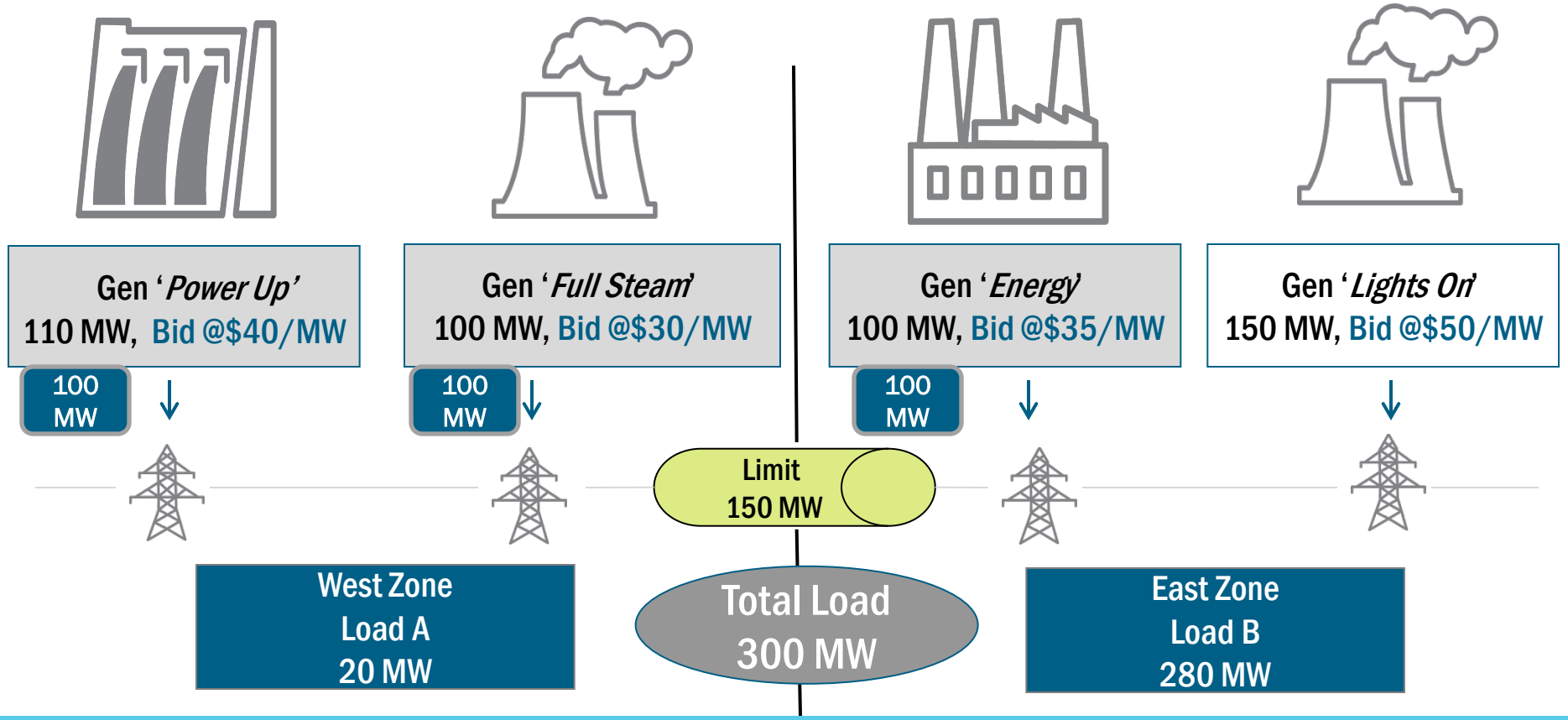
Example 2: Energy and Congestion



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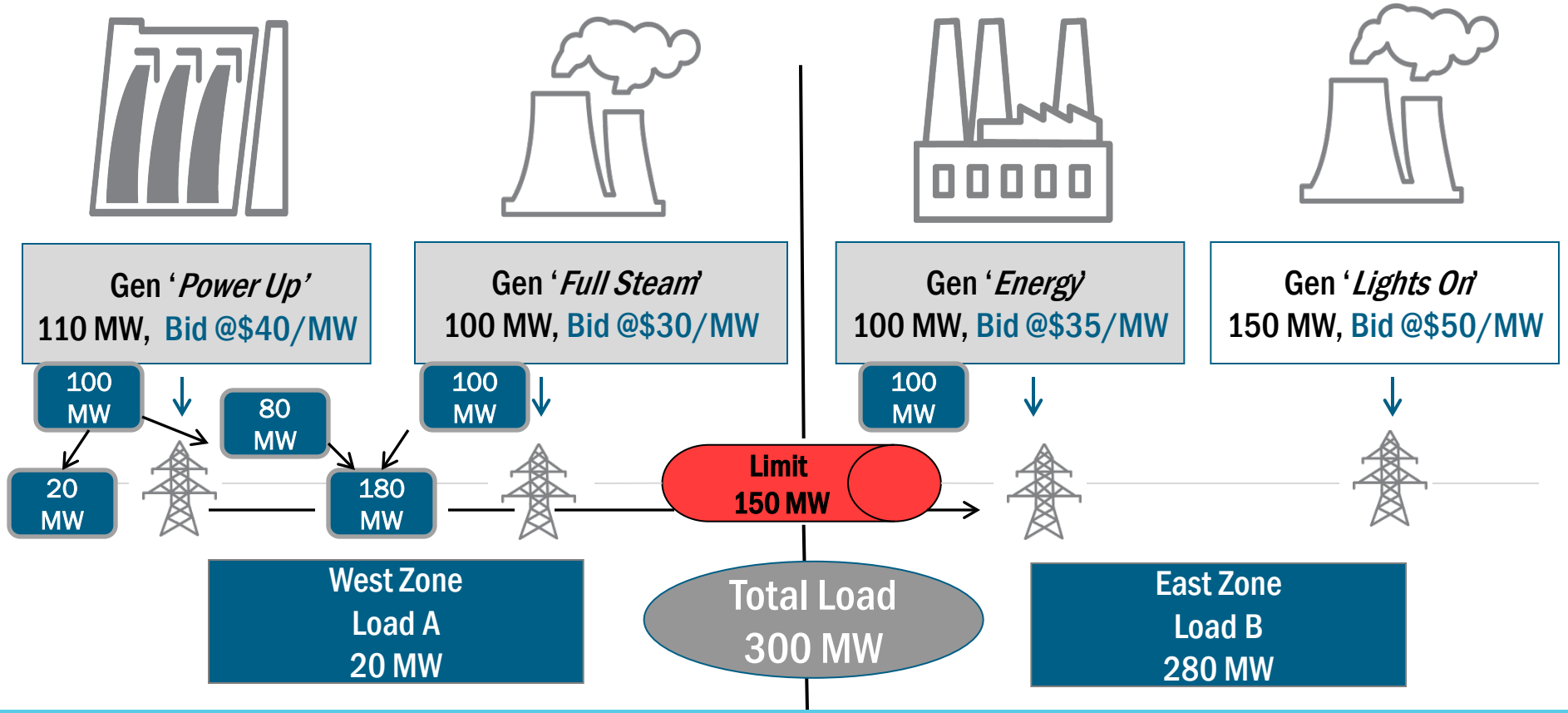
Example 2: Energy and Congestion



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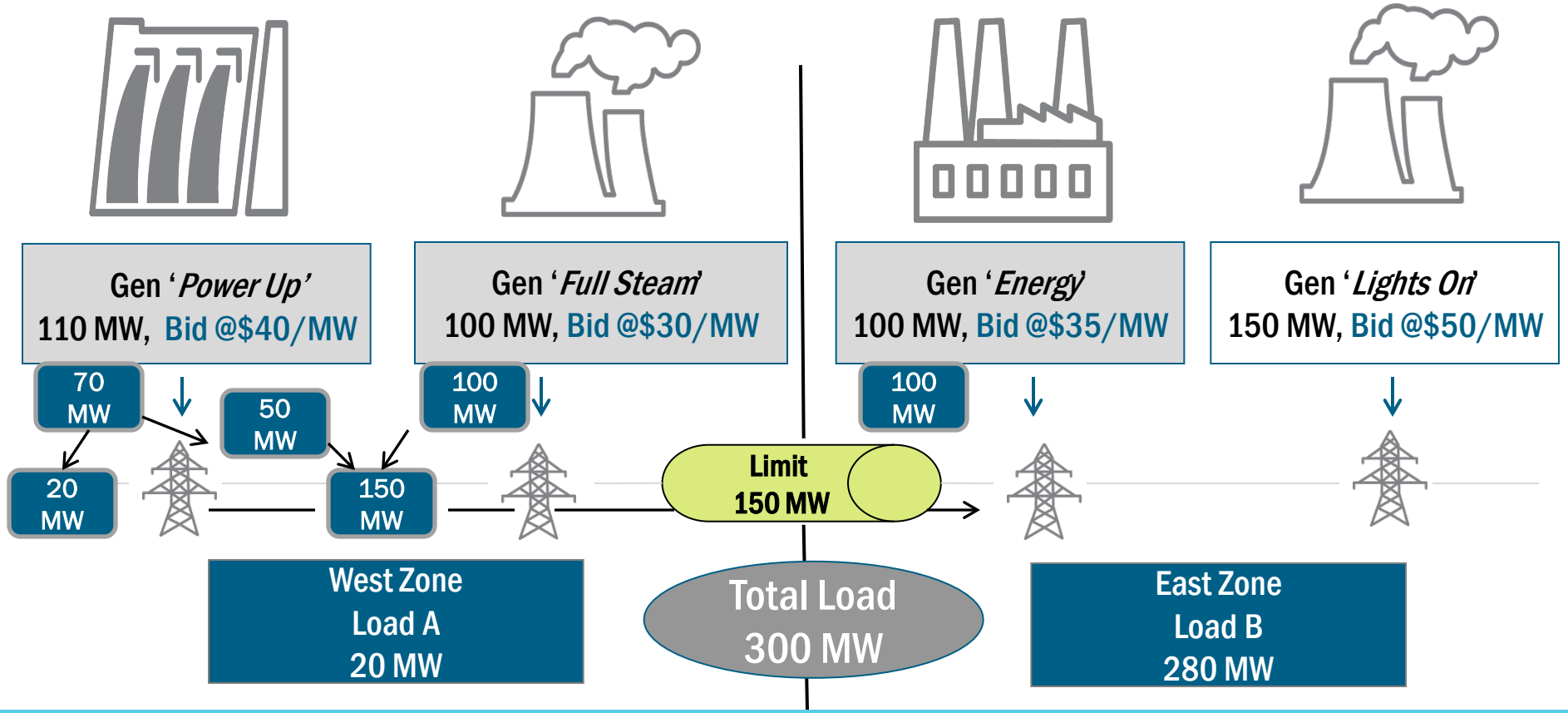
Example 2: Energy and Congestion



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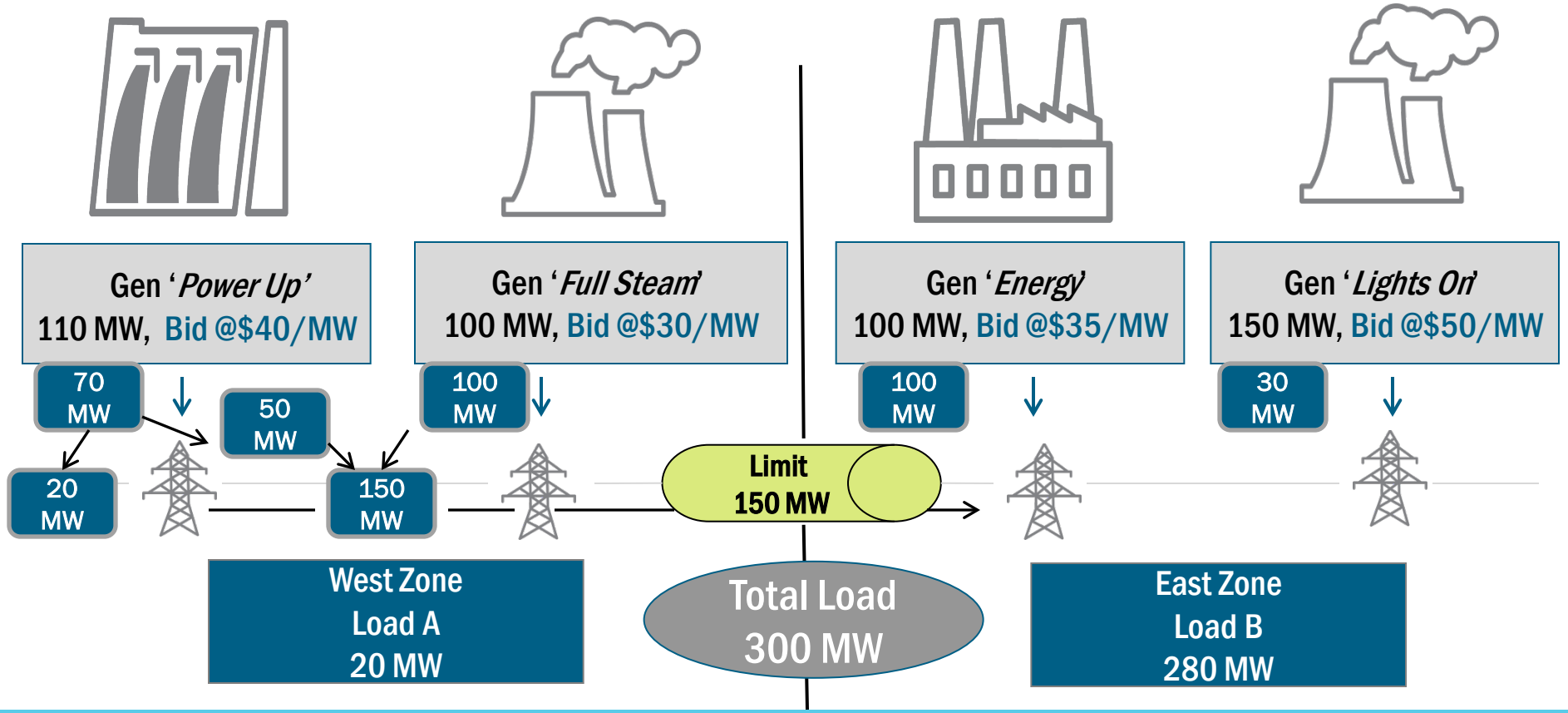
Example 2: Energy and Congestion



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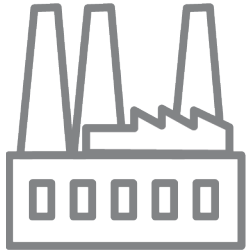
Example 2: Energy and Congestion - Results

Gen '*Power Up*'
110 MW, Bid @$40/MW

Gen '*Full Steam*'
100 MW, Bid @$30/MW



Gen '*Energy*'
100 MW, Bid @$35/MW

Gen '*Lights On*'
150 MW, Bid @$50/MW

Energy	$40.00
Loss	$0.00
Congestion	-$0.00
LBMP	$40.00

Limit
150 MW

West Zone
Load A
20 MW

Total Load
300 MW

East Zone
Load B
280 MW

Energy	$40.00
Loss	$0.00
Congestion	-$10.00
LBMP	$50.00

West Zone LBMP $40/MW

East Zone LBMP $50/MW

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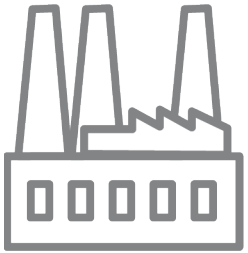
Example 2: Energy and Congestion -Results

Gen '*Power Up*',110 MW
Bid $40, Paid $40

Gen '*Full Steam*' ,100 MW
Bid $30, Paid $40



Gen '*Energy*' ,100 MW
Bid $35

Gen '*Lights On*', 150 MW
Bid $50

West Zone

East Zone

Generators in the West receive $40/MW (LBMP)

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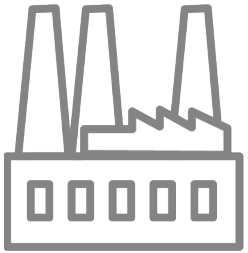
Example 2: Energy and Congestion -Results

Gen '*Power Up*',110 MW
Bid $40, Paid $40

Gen '*Full Steam*' ,100 MW
Bid $30, Paid $40



Gen '*Energy*' ,100 MW
Bid $35, Paid $50

Gen '*Lights On*', 150 MW
Bid $50, Paid $50

West Zone

East Zone

Generators, East of the interface receive $50/MW (LBMP)

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Example 2: Energy and Congestion - Results

Loads in West Zone
Charged $40/MW (LBMP)

West Zone
Load A
20 MW

Loads in East Zone
Charged $50/MW (LBMP)

East Zone
Load B
280 MW

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Let's Review

Image provided by 'The Extend Activity Bank
https://extend-bank.ecampusontario.ca/

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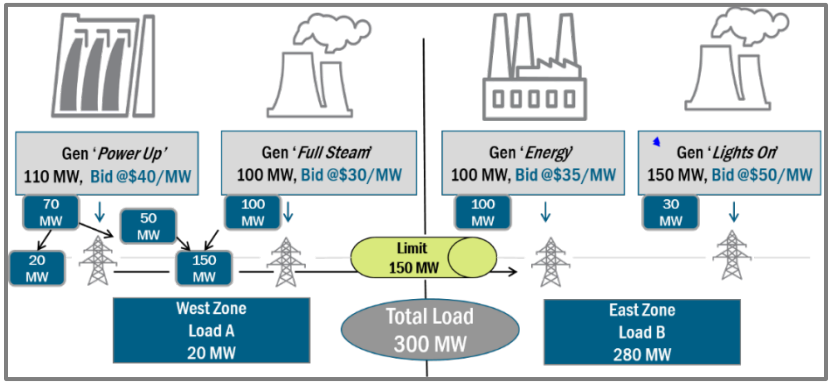
Example 2: Energy and Congestion – Results

West Zone LBMP
= $40/MW



East Zone LBMP
= $50/MW

	Total MWs injected/withdrawn (MWh)	LBMP ($/MWh)	Total $	
Credit to Gens in West	_____	_____	_____	Total Paid = _____
Credit to Gens in East	_____	_____	_____	
Charge to Load in West	_____	_____	_____	Total Charged = _____
Charge to Load in East	_____	_____	_____	

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Price Validation

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Price Validation – Procedures for Correcting Erroneous Prices

New York ISO

- Price Validation – Review and Correction of Day Ahead and Real Time Energy and Ancillary Services prices and price components
  - In accordance with the rules set forth in Section 20, Attachment E of the Market Services Tariff (MST)
  - To ensure accurate and transparent market signals, and to ensure market certainty
    - Timely review of prices for accuracy and release or correction of prices in a tariff defined timeframe

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Prices Validated

New York ISO

Energy Prices

DAM, RTC and RTD LBMPs at Zonal and Gen Bus level

Ancillary Services Prices

Regulation and Reserves by Reserve product type and location

Price Component Inputs

- Marginal Energy Price
- Loss factors (relative to Ref. Bus)
- Shift Factors
- Shadow Prices
- NYCA Regulation
  - Regulation Capacity
  - Regulation Movement (RTC & RTD only)
- Spinning Reserve
- Non-Synchronous Reserve

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What Makes a Price Accurate?

- An accurate price is one which is:
  - Correctly calculated per the rules defined in NYISO's tariff
  - Based on the appropriate price setting resource
  - Posted to OASIS correctly

- Fewer than 0.10 % (one tenth of one percent) of all Real-Time intervals have resulted in a price correction since 2009

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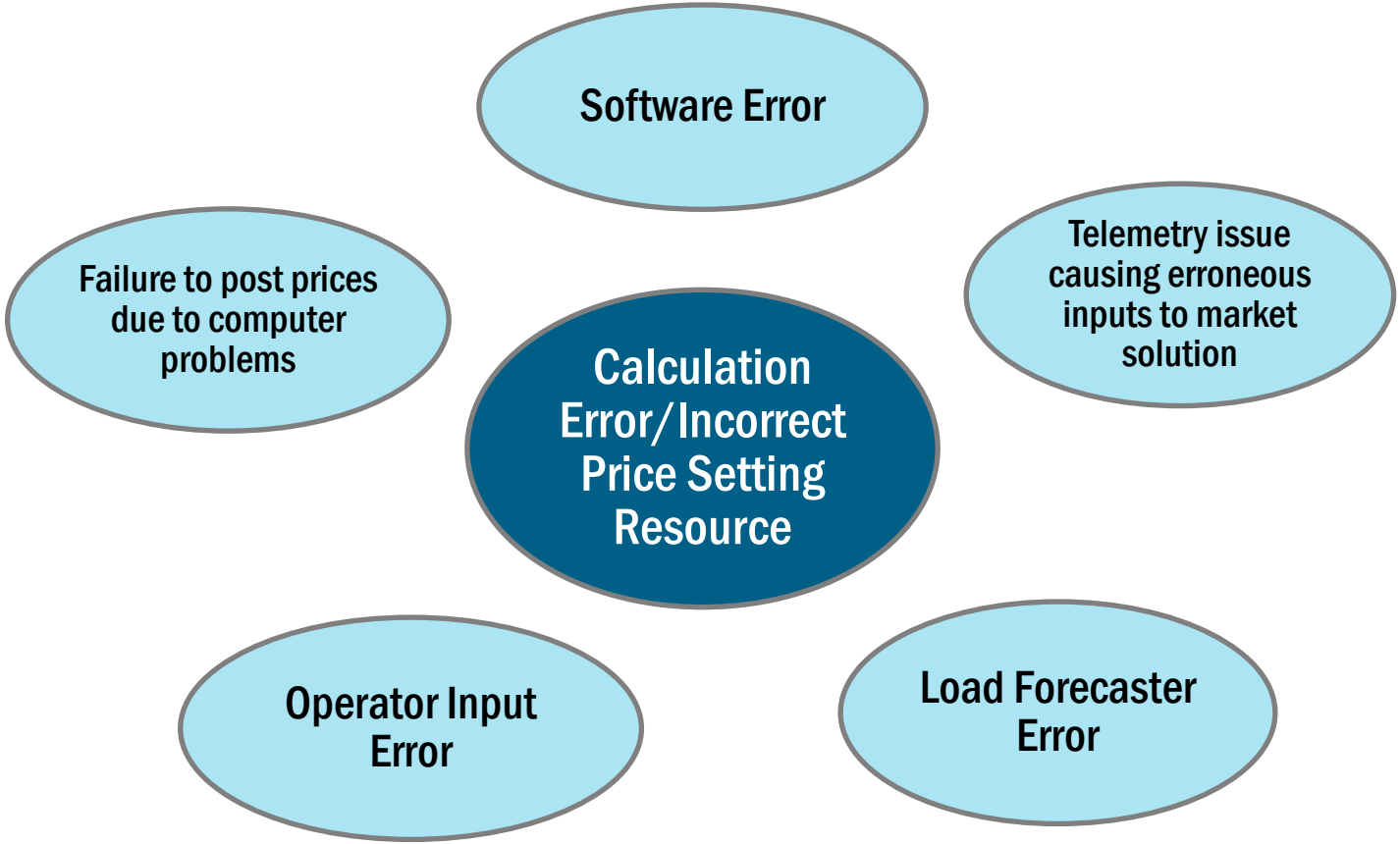
Price Errors: Some Examples



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Price Validation Process

1. Identify Suspects
   - Evaluate of all intervals through set of automated business rule comparisons by the Price Validation Rules Engine; intervals failing a rule tests flagged as suspects
2. Evaluate Suspects
   - Determine if suspect interval is correct, analyzing variety of data such as Load and DNI, Operator logs, constraints and limits, etc.
3. Dismiss, Reserve, Correct/Release Suspects
   - Reserve intervals that need further review correct or release prices before tariff-defined deadlines
     - 2 business days after market day for DAM prices, 4 business days after market day for RT prices
4. Correction Modes
   - Replace with surrounding interval price, RTD level advisory prices, similar bus prices, or prices from other markets (RTC or DAM)
   - Recalculate
   - Re-post

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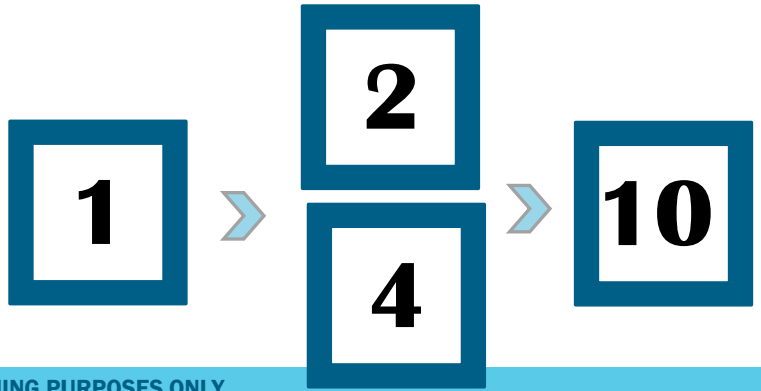
Price Validation Timeline

- Market participants are notified in a timely manner
  - One day to reserve potentially erroneous prices
  - Business days after the market day to correct or release reserved prices
    - 2 business days (Day Ahead prices)
    - 4 business days (RT prices)
  - Ten calendar days, following the price correction, to report the cause and type of correction applied



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LBMP and Price Validation – NYISO Website Data

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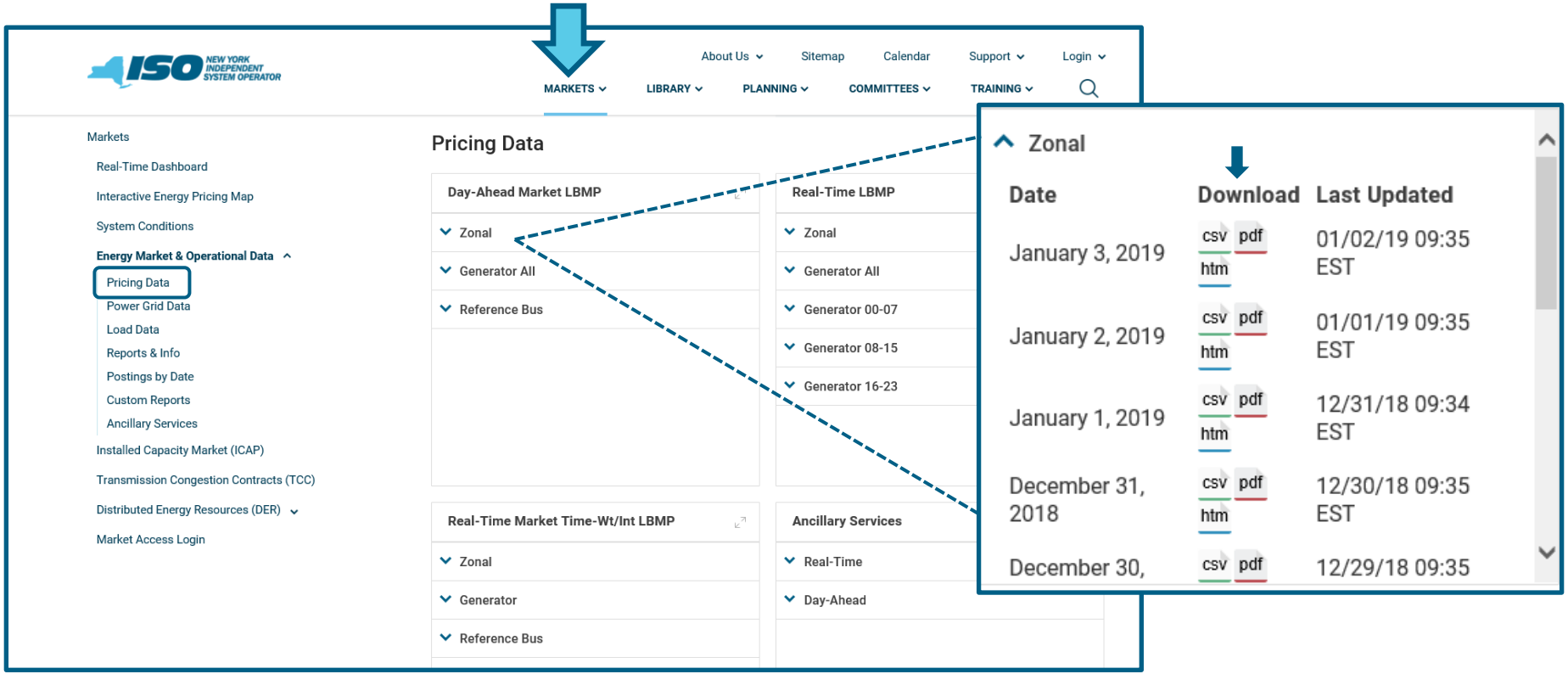
LBMP Data Files



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LBMP Components Data Files

Day Ahead Market Zonal LBMP

--- LBMP $ --- Marginal Cost of Losses --- Marginal Cost of Congestion

Zonal Data 12/05/2017

Name	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
PTID	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST	EST
CAPITL	29.72	25.19	25.98	23.15	24.45	22.61	27.54	28.15	27.81	31.93	31.91	27.75	28.93	28.11	28.85	28.06	34.82	38.63	34.29	32.65	31.82	26.66	25.41	24.62
61757	0.28	0.27	0.27	0.27	0.27	0.37	0.83	1.38	1.73	1.69	1.63	1.68	1.67	1.65	1.51	1.65	1.97	2.71	2.35	2.23	1.97	1.58	0.99	0.40
	-25.19	-20.68	-21.48	-18.63	-19.95	-16.96	-14.55	-5.94	-2.13	-6.40	-6.33	-2.40	-3.81	-2.94	-6.07	-3.56	-5.89	0.24	0.20	0.09	-2.45	-2.77	-9.35	-17.78
CENTRL	6.88	6.40	6.46	6.19	6.30	7.13	13.94	21.78	24.28	24.59	24.65	23.99	23.90	23.86	22.00	23.34	27.73	36.19	32.14	30.60	27.71	22.57	16.07	8.37
61754	0.03	0.02	0.01	0.03	0.01	0.10	0.27	0.39	0.34	0.31	0.26	0.29	0.26	0.24	0.23	0.28	0.30	0.40	0.29	0.22	0.17	0.07	0.11	0.09
	-2.60	-2.14	-2.22	-1.92	-2.06	-1.75	-1.51	-0.54	0.01	-0.44	-0.43	-0.04	-0.19	-0.09	-0.49	-0.21	-0.47	0.36	0.29	0.13	-0.14	-0.20	-0.90	-1.84

	CAPITL 61757	CENTRL 61754	NYISO_LBMP_REFERENCE 24008
LBMP	27.54	13.94	12.16
Loss	0.83	0.27	0.00
Congestion	-14.55	-1.51	0.00

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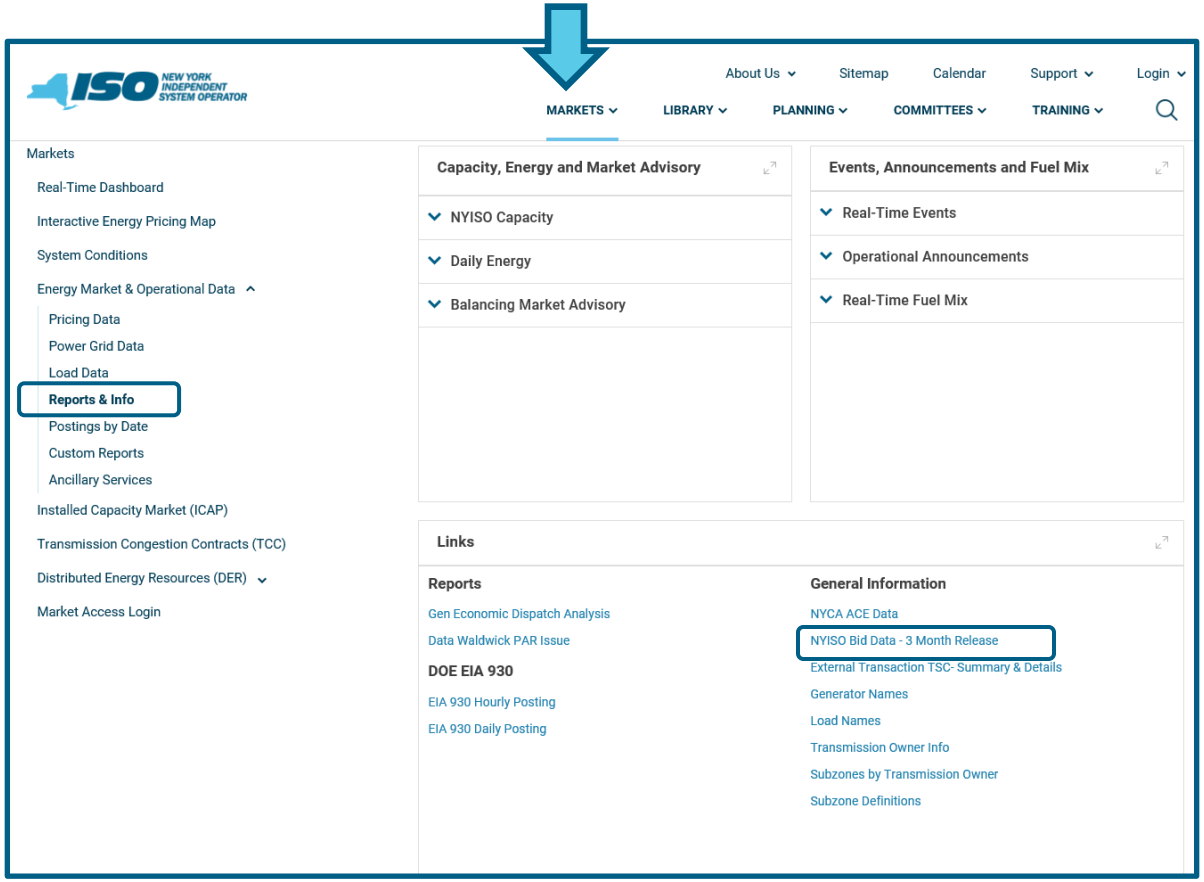
NYISO Bid Data – 3 Month Release



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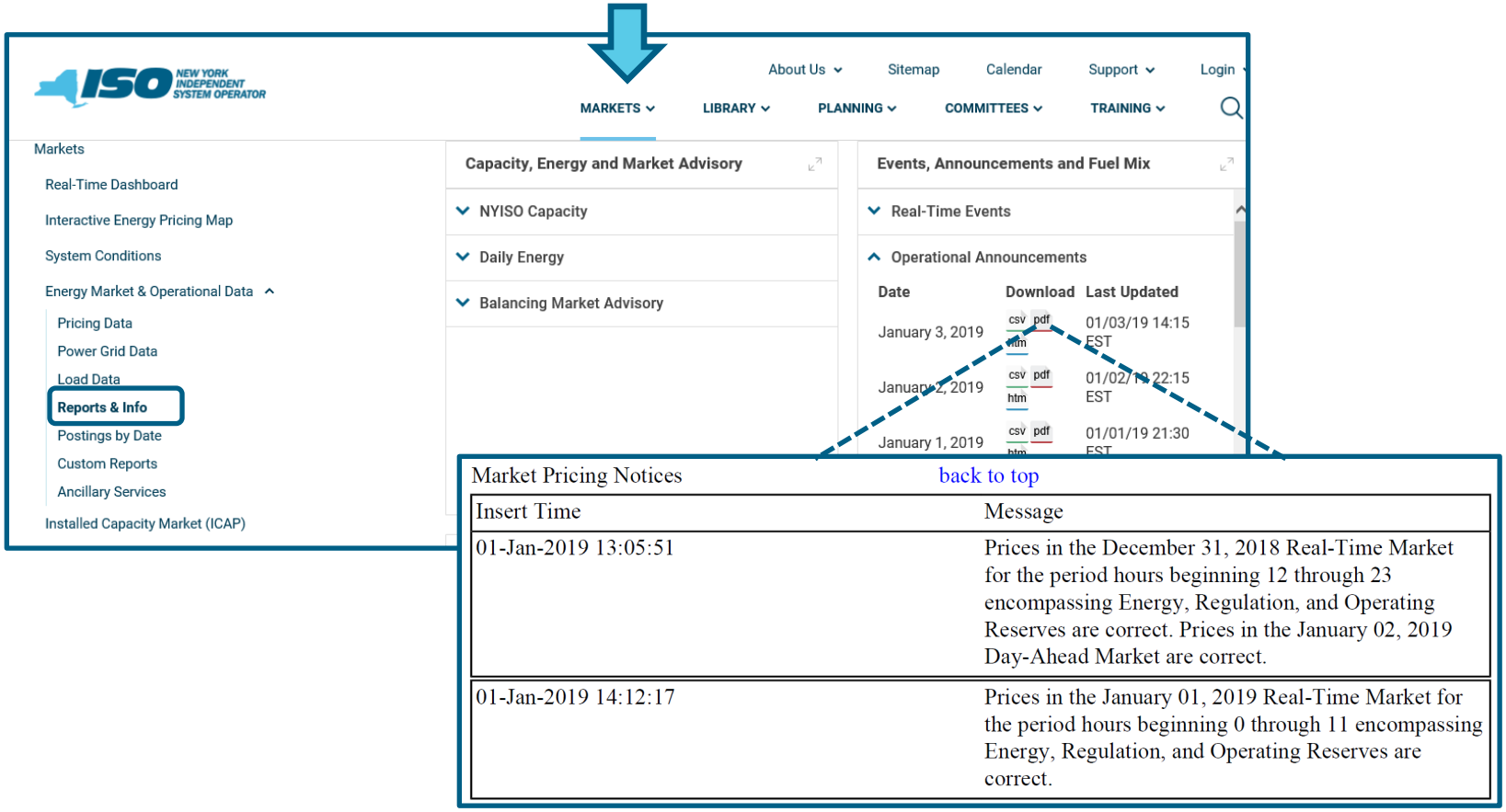
Market Price Validation Notices



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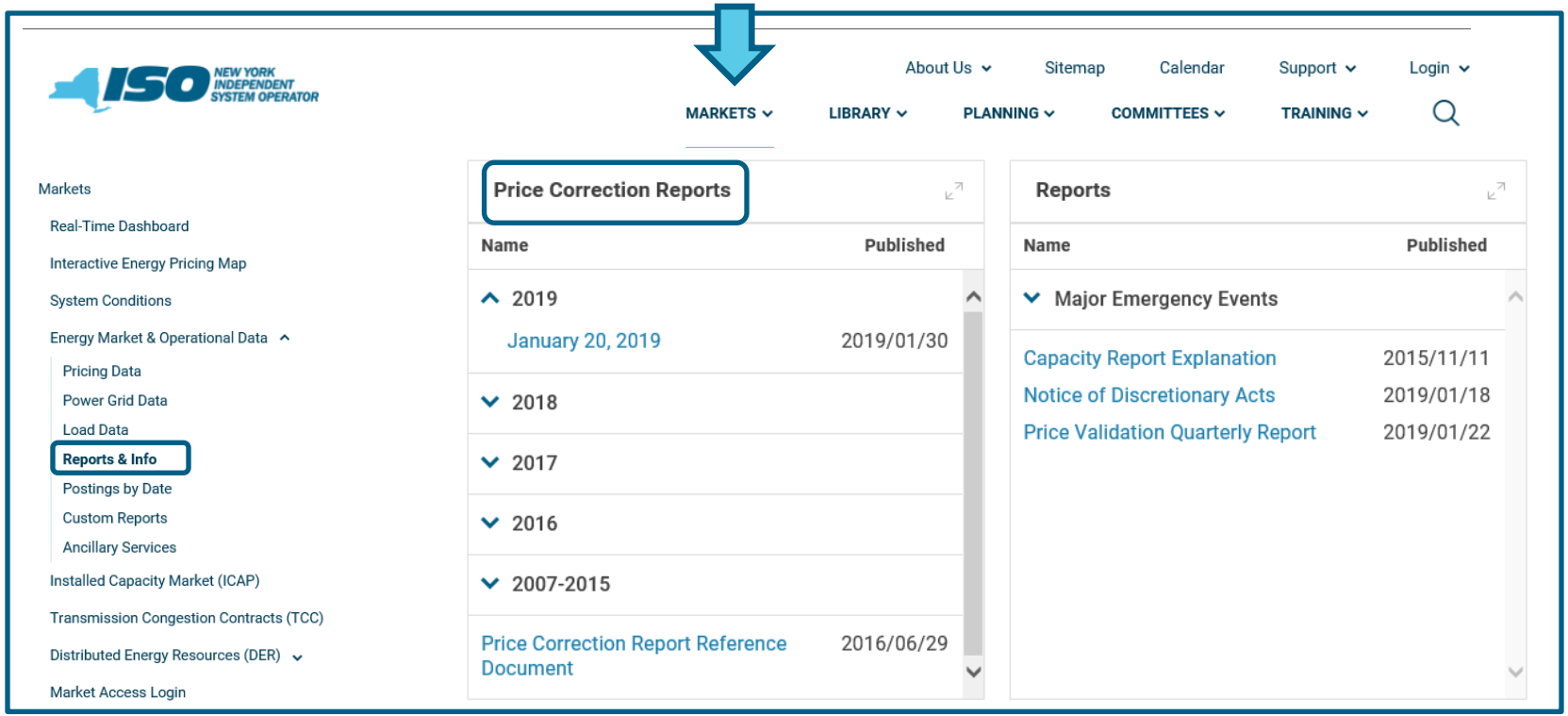
Price Correction Reports



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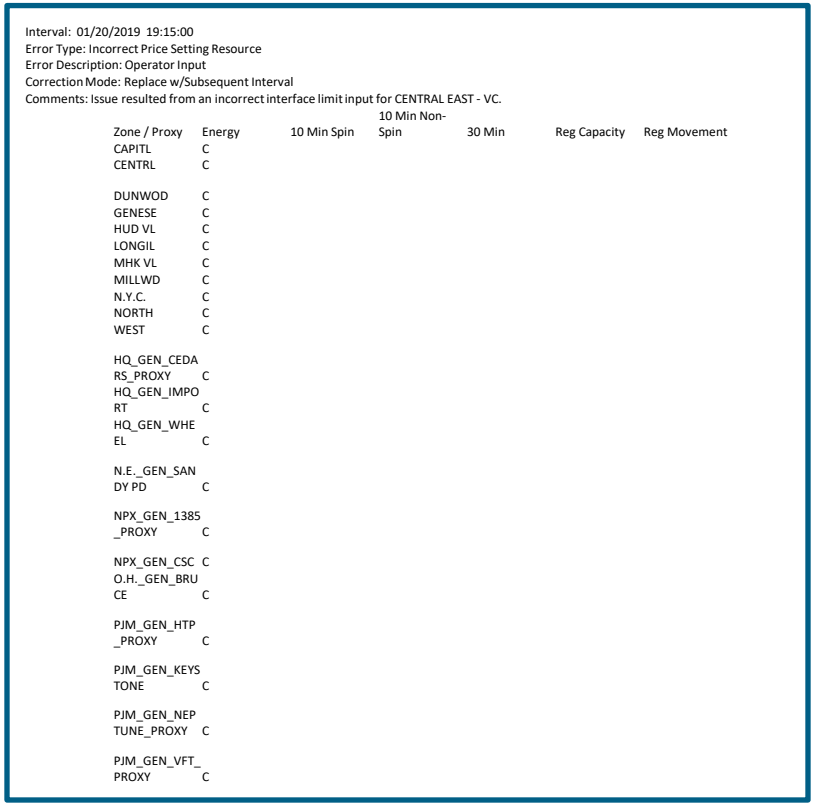
RT Price Correction Report Cont'd

- Report data includes:
  - Timestamps
  - Error Type
  - Error Description
  - Correction Mode
  - Affected Zones/External Proxies
  - Affected Ancillary Services
  - Additional Comments



Interval: 01/20/2019 19:15:00
Error Type: Incorrect Price Setting Resource
Error Description: Operator Input
Correction Mode: Replace w/Subsequent Interval
Comments: Issue resulted from an incorrect interface limit input for CENTRAL EAST - VC.

Zone / Proxy	Energy	10 Min Spin	10 Min Non-Spin	30 Min	Reg Capacity	Reg Movement
CAPITL	C					
CENTRL	C					
DUNWOD	C					
GENESE	C					
HUD VL	C					
LONGIL	C					
MHK VL	C					
MILLWD	C					
N.Y.C.	C					
NORTH	C					
WEST	C					
HQ_GEN_CEDARS_PROXY	C					
HQ_GEN_IMPORT	C					
HQ_GEN_WHEEL	C					
N.E._GEN_SANDY PD	C					
NPX_GEN_1385_PROXY	C					
NPX_GEN_CSC	C					
O.H._GEN_BRUCE	C					
PJM_GEN_HTP_PROXY	C					
PJM_GEN_KEYSTONE	C					
PJM_GEN_NEPTUNE_PROXY	C					
PJM_GEN_VFT_PROXY	C					

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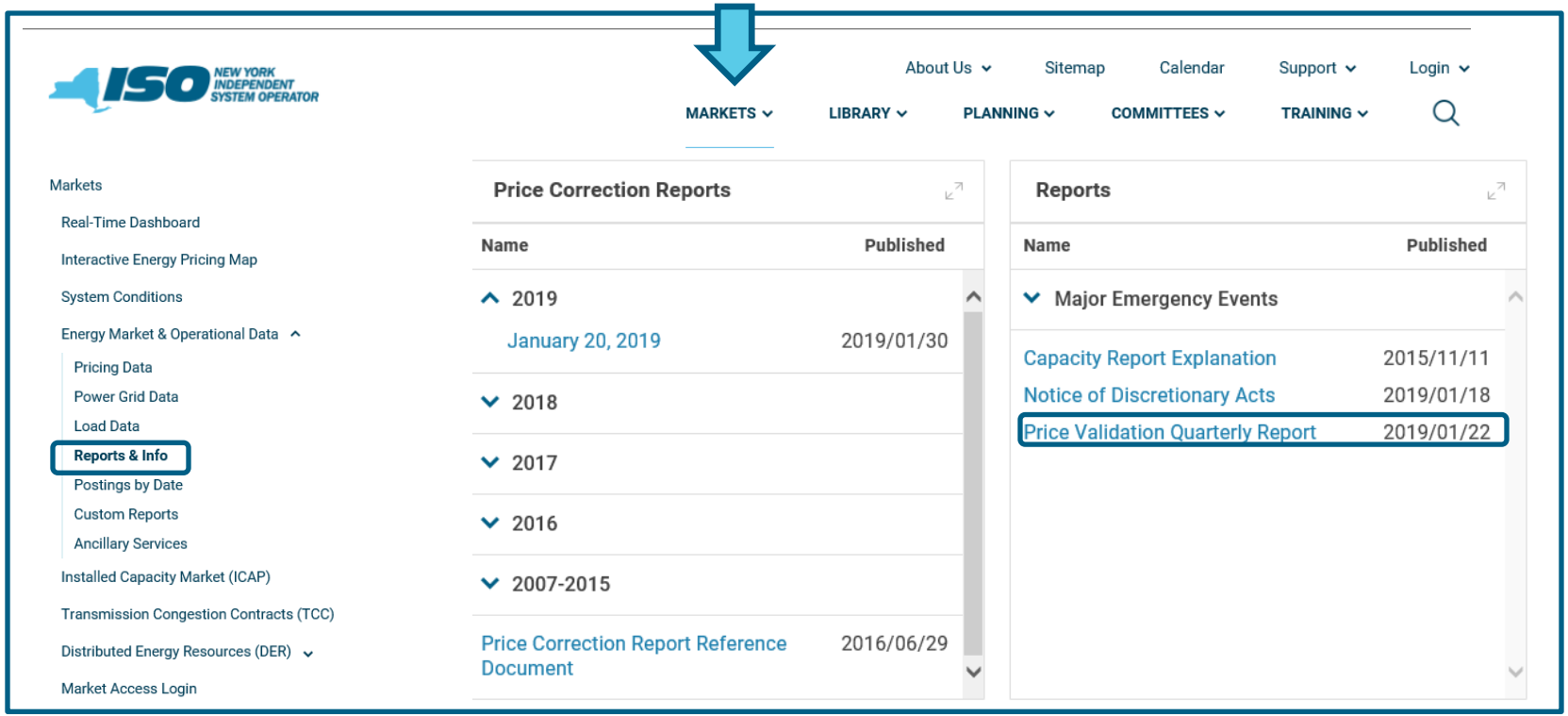
Price Validation Quarterly Reports



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Locational Based Marginal Pricing

- SESSION OBJECTIVES:
  - Understand the Basics Behind LBMP
    - Definition
    - Show how LBMPs are Established
    - Name the Three Components of LBMP
  - Complete Examples that Demonstrate LBMP Concepts
  - Learn about the process of Price Validation

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Additional Resources

- Tariffs - OATT & MST
- Day Ahead Scheduling Manual
- Transmission and Dispatching Operations Manual
- Market Participant User's Guide
- Technical Bulletins

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